DRAFT FOR APTA USE

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transit sustainability practice compendium

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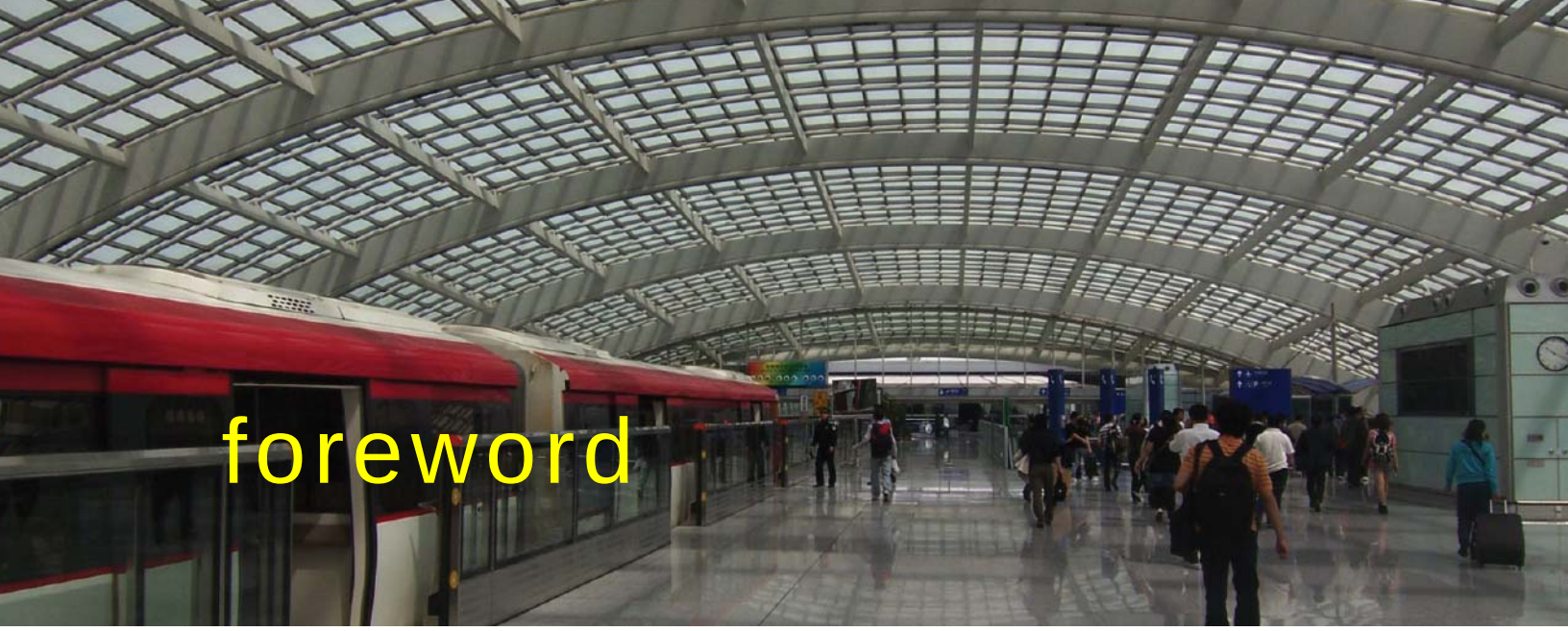

foreword

The work of developing these guidelines was inspired by the challenges I have faced in my journey to green the Bay Area Rapid Transit District (BART). After the formulation and adoption of BART Sustainability Policy in 2002, I began to explore the next steps for greening BART in a systematic way. In 2004, we developed and incorporated a guideline section entitled "Environmental Design and Sustainability" into our new systemwide BART Facilities Standards (BFS) for all capital projects. Although the Sustainability Policy addressed BART's unique role in regional community sustainability, the guidelines were modeled after LEED and therefore primarily building industry-based sustainable practices. Over the first three years of the application of the BFS, BART made good progress in furthering its environmental goals. This progress was documented by an US EPA Innovation Grant project. Although the report quantitatively showed that significant environmental benefits had been achieved in conventional material and energy aspects, the report challenged us to demonstrate that these benefits had made a direct impact in regional sustainability through enhanced mobility and reduction of VMT[1] as the Sustainability Policy called for. For example, the total amount emission and noise avoided through the over 45 documented projects was negligible when compared to what one automobile can generate. In order to achieve true sustainability we must take a more holistic approach toward what a transit agency could and should contribute. A new vision and a new set of practice guidelines were needed to help us:

- stay in touch with the latest trend of mobility and best transit practices around the world,
- depart from "business as usual", and
- go beyond simply adopting existing standards not designed specifically for the important role of transit can play in sustainability.

1 Vehicle Miles Traveled by an automobile.

Designing and operating sustainable transit requires a new way of thinking. Improving transit systems' performance and integrating transit with community development in many cases is more vital than a simple reduction of the environmental footprint of agency facilities. A transit system can comprise the greenest of earth-friendly, energy-efficient facilities and fleet, but it does little good if people keep choosing their automobile instead of taking the train or bus. An empty bus cannot be a sustainable bus. If transit doesn't succeed in integrating and serving the community, it can actually be an environmental and economical burden and even a scar upon the landscape. On the other hand, there are systems around the world that have successfully integrated with and served their communities. While they have reduced transportation's environmental footprint, they have also enhanced the quality of life of the community by making people's travel more enjoyable and affordable or, in many cases, reduced the need for commute and other automobile trips. A holistic practice of transit sustainability leads to a healthier and happier life style and a more livable community.

The underlying reason behind these Transit Sustainability Guidelines is to communicate the belief that we need to do everything in the realm of sustainability which is within the control or influence of transit agencies. This will require vision and, sometimes radical, innovation. For example, currently it takes too long to plan and build transit systems in the US. The process can take from one to two decades, consuming too much of the public's resources. It results, at least in part, in less funding for constructing quality facilities and procuring state-of–the-art fleets. Another problem needing innovation is that lack of rigorous and timely integration of transit system development and community development, often resulting in poor performance. It creates the negative cycle of poor ridership, poor funding, poor service, poor modal availability, poor community development, and poor livability. These guidelines are intended to be part of the solution, where urban/suburban planning and transit planning only proceed with consideration of the other.

In 2005, with the conviction that it was necessary to develop a set of industry-wide transit specific sustainability guidelines, I reached out to my colleagues in other transit agencies and consultants and organized a number of inter agency meetings and interdisciplinary conferences on sustainability, public transit, and livable communities. During the next two years, a frame work for the guidelines had began to form, largely influenced by my experience at BART and my study of European, Asian, and North American transit systems. In 2007, with a funding from US EPA and support of BART, NYCT, LA Metro, TriMET, and MARTA, we assembled the first face to face working session and formed a multi-agency group for developing the guidelines. In 2008, APTA provided additional resources to enable the formation of a broader team covering greater diversity of transit, region, expertise, and sectors. More importantly, APTA included the guidelines as a part of their overall standard development effort for sustainability. As of today, the following entities and representatives have taken part in the work of our team:

> ***Federal Government***: US Environmental Protection Agency (EPA) - Jennifer Blonn, Carolyn Mulvhill, and Timonie Hood.

Industry Association: American Public Transportation Association (APTA) - Rich Weaver, Jeff Hiott, and Petra Mollet.

Transit Agencies: Chicago Transit Authority (CTA) - Check Webber; Los Angeles Metro (LA Metro) - Aspet Davidian; Metropolitan Atlanta Rapid Transit Authority (MARTA) - Jayant Patel and Nick Lawrence; Miami Dade Transit (MDT) - Albert Hernandez; New York City Transit (NYCT) - Thomas Abdallah and Judith Kunoff; Regional Transportation District of Denver (RTD) - Andy Mutz; San Francisco Bay Area Rapid Transit District (BART) - Tian Feng; Toronto Transit Commission (TTC) - Susan Reed Tanaka; South Coast British Columbia Transportation Authority of Vancouver (TransLink) - Michelle Blake; Tri-County Metropolitan Transportation District of Portland (TriMET) - Bob Hastings; and Washington, DC, Metropolitan Area Transit Authority (WMATA) - Joan LeLacheur.

***State Government*:** Florida State University (FSU) - Melanie Simmons, Florida Department of Health (DOH) - Daniel Parker, and Florida Department of Transportation (DOT) – Diane Quigley.

International Consulting Firms: Bechtel - Patricia Gaither; Jacobs Engineering Group - Mary Nowee and Bob Highfill; HDR - Lauren Casey; Parsons Brinckerhoff - Susannah Kerr Adler; and VIA Architecture - Catherine Calvert and Alan Hart.

Acknowledgement: I want to thank US EPA for their vision and Innovation Grants in supporting the launch of this initiative and their Region 9 staff members' outstanding and selfless contribution, such as Timonie Hood and Jennifer Blonn, since its inception. I want to commend APTA's management and staff's strategic approach in funding our group and in integrating our work as a part of APTA's broader sustainability program. I want to acknowledge all our members for bringing in their distinguished expertise and insight to the Guidelines, especially Mary Nowee, Bob Highfill, Michelle Blake, Catherine Calvert, Judith Kunoff, Tom Abdallah, Bob Hastings, Jennifer Blonn, and Lauren Casey for their invaluable editorial assistance. Finally I want to express my gratitude to my employer, BART, for challenging me to green BART as early as when I began my career there in 2001 and supporting me in leading this important initiative.

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introduction

Transit Sustainability within the context of this document - The sustainability practices by transit industry should aim at having broader impact through the following:

1. Improving mobility via improved and enjoyable transit services
2. Reducing per capita automobile vehicle mile traveled
3. Reducing passenger transportation-generated CO^2 and other greenhouse gases
4. Creating livable communities through facilitating more environmental friendly forms of mobility such as walking, biking, and public transit. Increasing the number of routine destinations that are accessible safely and comfortably by walking, biking and public transit.
5. Reducing passenger transportation-caused ambient hazards such as noise, particulates in the air, vibration, physical threats, and mental stress to the public in general and particularly to pedestrians.
6. Reducing stress, loss of productivity, and traffic deaths and injuries and related health care costs caused by automobile travel.

The guidelines introduced in this document are designed to address transit practices that will lead to realization of the above sustainability objectives.

Some transit operators can further the above objectives through the planning, designing, constructing, and operating their system's routes, infrastructure, facilities, fleet, and services. In addition, by leveraging their properties, services, and funding structure, these operators should reach out to their municipal partners, community organizations, and business associations to further the above objectives through coordinated efforts. Other transit operators, as service providers, can offer innovative services that push their hiring agencies towards greater impact in regard to these broader goals.

Transit systems have typical components, although they may vary between transit service providers, a transit system generally consists of the following four components:

1. **System route and transit node**
   - Rail transit has track or guideway and station site;
   - Bus transit shared or dedicated roadway and stops,
   - Ferry transit has course across designated waterway and terminal area.
2. **Infrastructure and facilities**
   - Rail transit has track and right of way, and civil, power and communication systems, and all revenue and non-revenue facilities supporting transit operations;
   - Bus transit has roadway and communication system, and all revenue and non-revenue facilities supporting transit operations;
   - Ferry transit has communication system, and all revenue and non-revenue facilities supporting transit operations;

definitions

community: In context of these Guidelines, community is 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.

mobility: Ability of transporting 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, note that In America the majority of passenger transport is automobile based .

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

3. **Rolling stock and fleet**
   - Rail transit has train (assembly of rail cars) for revenue service and significant amount of non-revenue rail and rubber-tire vehicles supporting maintenance and operations;
   - Bus transit has buses as well as supporting vehicles;
   - Ferry transit has vessels.

4. **Transit operates as a system**
   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 operating the system holistically.

About the structure of the guidelines: In response to the uniqueness of transit systems and transit operations, the guidelines are organized for ease of understanding by transit professionals, while still providing context to help professionals in related fields. The document focuses on guidelines which are specific and significant to transit practices, while including as Reference Standards other sustainability guidelines that are not designed for the transit industry, but are applicable to many aspects of transit facilities and operations, such as the LEED Rating System and ISO 14000.

The guidelines have been developed by individuals who will be this document's audience themselves – transit agency staff and consulting professionals. The development team welcomes comments and contributions from those who read and apply the guidelines and further welcomes their participation in future revisions and enhancement of the guidelines.

It is the intent of these guidelines to provide transit agencies with best practices for improving the sustainability of transit systems while providing high quality transit service. These guidelines address all modes of transit and all service areas. Recommended practices consider the degree of control or influence transit agencies have in particular areas as well as expected environmental and social improvements.

Recommended guidelines incorporate the knowledge of a diverse team of public and private sector transit experts, including architects, engineers, planners, and other technical experts from the U.S. and Canada. These guidelines also include insights from established sustainability standards, policies, and published reports. These guidelines are intended to be a living document; they will be updated and expanded as newer technologies and more information become available. Due to the wide variance between transit systems, extensive 'how-to' guidance is limited. Rather, strategies and practices for improved performance are presented and analyzed. Where possible, case studies are shared.

This document is intended for:

- Agency management and those with decision-making authority,
- Public and private sector project and operations professionals,
- Municipalities and communities, and
- Owners and developers of land where transit projects are sited.

These guidelines are intended to be used as:

- An informational resource for (1) policy makers seeking a holistic approach to environmentally sustainable transit and (2) transit professionals, municipalities and communities looking to become more informed,
- A reference to promote a common language and maximize 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.

Sections 2 through 5 are organized to reflect the sequence of creating, operating, and maintaining transit systems. Topics addressed include:

- Section 2: System Route, Transit Mode and Node
- Section 3: Infrastructure & Facilities,

- Section 4: Rolling Stock/Fleet, and
- Section 5: Operations & Maintenance.

Sections 2 through 5 address the five sustainability aspects defined below and depicted in the matrix in Figure 1. Definitions provided for each aspect further limit the scope of this document. When appropriate, guidelines reference specific modes, including bus, rail and ferry.

- ***System Planning, Land Use, & Site Design:*** Includes land use impacts, such as opportunities that result from transit operations.
- ***Materials:*** Includes material selection, design, construction, and fabrication of all physical elements. Includes material selections used in operations, such as cleaning products and chemicals.
- ***Energy:*** Includes electricity and fuel consumption, renewable energy resources, and energy efficiency and optimization (excludes emissions).
- ***Ambient Environment & Health:*** Includes rider experience, system cleanliness, place making, and accessibility.
- ***Emissions & Pollution Reduction:*** Includes all emissions, fuel, chemical use, waste, and other sources of pollution.

Figure 1: Organization of Sections 2 - 5

Section Topics *(Transit Elements)*	***Subsection Topics*** *(Sustainability Aspects)*				
	Systems Planning, Land Use, & Site Design	**Materials**	**Energy**	**Ambient Environment & Health**	**Emissions & Pollution Reduction**
SECTION 2: System Route, Transit Mode & Node	***	*	**	***	*
SECTION 3: Infrastructure & Facilities	**	***	**	***	**
SECTION 4: Rolling Stock & Fleet	*	***	**	***	**
SECTION 5: Operations & Maintenance	*	*	**	**	***

Note:
* Low Impact to Sustainability
** Impact to Sustainability
*** High Impact to Sustainability

guideline overview

The following checklist provides an overview of each guideline included in the following sections.

SYSTEM ROUTE, TRANSIT MODE & NODE

System Planning & Land Use

- ☐ Consider Land Use Context
- ☐ Engage the Public Early
- ☐ Coordinate Modal Integration
- ☐ Optimize Parking
- ☐ Develop a Partnership for Transit Oriented Development or Mobility Enhanced Development
- ☐ Scale Transit Appropriately
- ☐ Use Life Cycle Assessment to Address Grade Separation
- ☐ Promote Environmentally Friendly and Healthy Modes of Transportation

Energy

- ☐ Partner with Local Power Utility
- ☐ Consider Energy Consumption When Choosing Mode
- ☐ Design Alignment to Optimize Energy Use

Emissions & Pollution Reduction

- ☐ Plan to Minimize Noise and Vibration

INFRASTRUCTURE & FACILITIES

Materials

- ☐ Mitigate the Embodied Energy
- ☐ Ensure Appropriate Material
- ☐ Design for Service Life and Durability
- ☐ Design for Flexibility
- ☐ Use Recycled Materials
- ☐ Design for Low Maintenance
- ☐ Incorporate Innovative Sustainable Construction Practices

Energy

- ☐ Design for Energy Efficiency
- ☐ Partner with Local Power Utility
- ☐ Optimize Efficiency of Rail System
- ☐ Minimizing Transmission Losses
- ☐ Consider Innovative Approaches to Energy Usage

Ambient Environment & Health

- ☐ Provide Inviting Space/Art/Entertainment
- ☐ Enhance Wayfinding
- ☐ Provide Weather Protection
- ☐ Maximize Comfort and Safety

Emissions & Pollution Reduction

- ☐ Mitigate Hazardous Materials and Preserve Air Quality
- ☐ Design for Water Efficiency and Reuse
- ☐ Establish Green House Gas Monitoring on Facilities
- ☐ Implement Waste Management and Recycling
- ☐ Control Erosion

ROLLING STOCK & FLEET

System Planning & Land Use

- ☐ Consider Vehicle Choice in System Planning

Materials

- ☐ Incorporate Environmentally Preferable Materials
- ☐ Bus-specific Preferred Materials

Energy

- ☐ Complete Vehicle Design and Related Systems
- ☐ Rolling Stock and Fleet Operation
- ☐ Bus Rolling Stock Design

Ambient Environment & Health

- ☐ Inviting Space
- ☐ Bus Specific Experience
- ☐ Rail Specific Experience

Emission & Pollution Reduction

- ☐ Measure and Reduce GHG Emissions from Vehicle Operation
- ☐ Reduce Diesel Use in Bus Operations

OPERATIONS & MAINTENANCE

Energy

- ☐ Improve Energy Efficiency of Operations & Lower Peak Demand
- ☐ Use Renewable Energy Resources
- ☐ Energy Conservation
- ☐ Bus Operations & Maintenance
- ☐ Ferry Operations & Maintenance
- ☐ Rail Operations & Maintenance

Ambient Environment & Health

- ☐ Crowd Control and Riding Comfort
- ☐ Provide Clean and Attractive Vehicles, Stations, and Transit Nodes
- ☐ Provide Friendly and Courteous Operators

Emissions & Pollution Reduction

- ☐ Pollution Reduction Strategies
- ☐ Enhance Facility Performance and Longevity

2 system route, transit mode & node

introduction

The physical siting and 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 interests involved in transit system planning: users, operators, planning agencies, other government agencies and jurisdictions. A framework for the co-development of transit and land use planning should promote compact development patterns, encourage transportation choices, and optimize public investment in the transit line. Furthermore, planning for access and connectivity between all transportation modes, including bicycling and walking, promote transit as a viable alternative to automobile use.

There are multiple public health considerations related to System Route, Transit Mode and Node. The accessibility, safety, and physical activity associated with transit can enhance or detract from public health.

The following guidelines are intended to be read as principles to be utilized by an agency or agencies depending who has jurisdictional authority for land use and transportation.

This section, System Route, Transit Mode & Node, provides the following guidelines:

2.1 System Planning and Land Use

Guideline 1: Consider Land Use Context: Work with local municipalities to develop transit supportive land use policies

Guideline 2: Engage the Public Early with a Thorough Community Outreach Effort

Guideline 3: Coordinate Modal Integration: among rail, bus, ferry, pedestrian, and cycle routes to enhance system interconnectivity

Guideline 4: Optimize the amount of land devoted to parking

Guideline 5: Develop or coordinate an agency partnership for Transit Oriented Development and Mobility Enhanced Development

Guideline 6: Scale Transit Appropriately

Guideline 7: Use Life-Cycle Analysis to Address Grade Separation

2.2 Materials (N/A)

2.3 Energy

Guideline 1: Partner with Local Power Utility

Guideline 2: Consider Energy Consumption when choosing mode

Guideline 3: Design Alignment to Optimize Energy Use

2.4 Ambient Environment & Health

Guideline 1: Promote Environmentally Friendly and Healthy Modes of Transportation

2.5 Emissions & Pollution Reduction

Guideline 1: Plan to minimize noise and vibration

2.1 SYSTEM ROUTE, TRANSIT MODE & NODE

systems planning, land use & site design

Intent & Scope

This section provides guidelines 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 included. This integrated, process-oriented approach also introduces performance measures for evaluation criteria established under the FTA "New Starts" program.

Reference Standards

New Starts: The Federal Transit Administration's (FTA) discretionary New Starts program is the federal government's primary financial resource for supporting locally-planned, implemented, and operated transit "guideway" capital investments. The comprehensive planning and project development process is intended to assist agencies with the evaluation of alternative strategies for addressing transportation problems in specified corridors and in selecting the most appropriate improvement.[2]

Guidance on New Starts Policies and Procedures
www.fta.dot.gov/documents/Final_Guidance_NewStartsSmallStarts_Policies_Procedures(1).pdf

Reporting Instructions for the Section 5309 New Starts Criteria
www.fta.dot.gov/documents/tpeNewStarts_20080707_reportingInstructions.pdf

guidelines

Eight guidelines are provided for System Planning & Land Use under System Route, Transit Mode & Node, and are discussed in more detail in the following subsections:

guideline 1: Consider Land Use Context: work with local municipalities to develop transit supportive land use policies.

guideline 2: Engage the Public Early with a Thorough Community Outreach Effort.

guideline 3: Coordinate modal integration among rail, bus, ferry, pedestrian, and cycle routes to enhance system interconnectivity.

guideline 4: Optimize the amount of land devoted to parking.

guideline 5: Develop or coordinate an agency partnership for Transit Oriented Development and Mobility Enhanced Development.

guideline 6: Scale Transit Appropriately.

guideline 7: Use Life-Cycle Analysis to Address Grade Separation.

2 www.fta.dot.gov/planning/newstarts/planning_environment_2608.html

LEED© Neighborhood Development: LEED for Neighborhood Development provides guidance on community involvement, modal coordination, reducing parking, considering land use context, promoting compact development and community connectivity, and other elements of Systems Planning, Land Use, & Site Design decisions.

Draft LEED ND Guidelines can be found at:
www.usgbc.org/ShowFile.aspx?DocumentID=5275

2.1 GUIDELINE 1

Consider Land Use Context: Work with Local Municipalities to Develop Transit Supportive Land Use Policies

principles

- Using zoning to create transit-friendly development
- Conversion of existing car-dominated uses to transit-oriented development
- Using innovative granting processes to plan or build transit-friendly prototype developments

recommendation

Optimize public investment in transit lines through the coordination of land use policy with transit system planning and locate stations and transit nodes where they are best supported by existing or planned residential and/or commercial development.

- Set measurable targets for Station Areas and transit nodes such as mode split, density, and people per acre for commercial enterprise.
- Partner with local planning agencies to develop “comprehensive station area (or transit node) plans” that encourage densification and infill development.
- Engage members of the local/or national development community to proactively steer future development towards station and transit node sites.
- Develop working groups to audit existing land use codes to ensure compliance with the “5Ds;” Density, Design, Diversity, Distance to Transit, and Destination Connectivity. The 5 “D’s” summarize ideas related to the following:
- compact development and an appropriate threshold of residents/employees to support transit use;
- a pedestrian-oriented and rich walking environment that encourages alternative travel modes and sociability and provides a variety of ways to circulate the neighborhood;
- diverse, mixed land uses and a range of housing types;
- pedestrian routes which are well-connected to transit stations and nodes from homes and businesses with

pedestrian trips of an acceptable (short) duration;

- connections and access from the station area or transit node to other regional destinations such as shopping areas.
- Adopt urban design standards that promote community identity. Standards should encourage development at a human scale; appropriate community amenities; distinctive identity features such as historic patterns and buildings; appropriate cultural context and seamless connections to the surrounding neighborhoods.
- Incorporate adaptive reuse of historic structures where possible.
- Carefully consider location of ancillary buildings such as substations, maintenance facilities, etc. in terms of both operational efficiency and urban context.

context

An integrated approach to station and transit node area planning will support transit ridership by providing the transit agency with a resident population within walking distance of transit and provide further benefits such as improved public health, decreased traffic congestion, lower vehicle miles traveled (VMT) levels, and increased housing choice.

measurement

- Vehicle miles traveled by mode
- Commute costs per capita
- Siting Criteria: thresholds of density within station or transit node area; employment statistics within station or transit node area.
- Qualitative performance measures including aesthetics, street complexity, sociability, sunlight access, connectivity (distances between routes), and destination accessibility.
- Walking distances from number of housing units measured in minutes.
- Housing affordability
- Number of housing units/amount of commercial space planned in station or transit node area.
- Public health data

case studies

The ***Phoenix Transit-Oriented Development Overlay District*** zoning overlay encourages development close to light rail stations, which will enhance transit ridership and decrease automobile dependency by providing a complementary mixture and density of activity. The overlay district applies to all new land uses and development and prohibits or limits some uses that discourage transit ridership. It also adds requirements to promote a comfortable pedestrian environment. The overlay district ordinance is being updated to provide more flexibility to encourage more intense development in conjunction with start-up of the light rail system which began service in December 2008.
(www.valleymetro.org/images/uploads/lightrail_publications/TOD_Brochure.pdf)

The ***OC Transpo*** (Ottawa) has had success in siting Transitway stations in shopping malls. Over time, as more shoppers arrive by transit, land can be converted from parking use to increased development. Developers can create direct connections from the station to the mall. Shopping malls can be ideal focal points for transit stations. The mall is a relatively large concentration of both employment and shopping trip attractions. Transit riders can conveniently stop to do shopping on their way to work, or between transfers. The transit operator may be able to negotiate use of under-utilized mall parking spaces for transit park and ride.

The ***Delaware Valley Regional Planning Commission (DVRPC)*** in Philadelphia developed a program called the Transportation and Community Development Initiative (TCDI). TCDI grants are intended to support growth or redevelopment in socially or economically disadvantaged Delaware Valley communities. TCDI grants are intended for early stage planning, feasibility analyses, market studies, economic analyses, site design, and preliminary project design. These early planning activities are often difficult to fund through other sources. TCDI projects will receive priority consideration when applying for implementation funding through two existing transportation programs contained in DVRPC's Transportation Improvement Program (TIP): the Transportation Enhancements (TE) and Congestion Mitigation and Air Quality (CMAQ) programs. There are three funding categories: Planning and

Land Use Management (including multi-municipal planning and corridor studies); Reuse and Revitalization (including Main Street and brownfield redevelopment); and Transportation and Infrastructure (including bicycle/pedestrian projects and transit station improvements). (www.dvrpc.org/planning/tcdi.htm)

The ***San Francisco Metropolitan Transportation Commission (MTC)*** included a Transportation/Land-Use Platform in its 2030 Regional Transportation Plan (RTP). Developed in response to an extensive outreach effort by MTC, this platform encourages a stronger linkage between transportation and land use planning. The Transportation/Land Use Platform is designed to encourage land use policies and practices that maximize walking, bicycling, and transit ridership and other forms of high-occupancy-vehicle travel, while reducing the need to travel long distances and reducing vehicle-related air pollution. (www.mtc.ca.gov/planning/2030_plan/)

more information

Municipal Research and Services Center Washington
http://www.mrsc.org/Subjects/Transpo/transitdev.aspx

Local Government Commission, Sacramento
www.lgc.org

Victoria Transport Policy Institute
http://www.vtpi.org/tdm/tdm45.htm

CALTRANS searchable TOD database
http://transitorienteddevelopment.dot.ca.gov

Bay Area Transit And Land Use Coalition- Great Communities Collaborative
http://www.transcoalition.org

Reconnecting America
http://www.reconnectingamerica.org

Portland TOD Zoning
www.planning.ci.portland.or.us/zoning/ZCTest/400/450_Transit.pdf

DART – Westmoreland Station (Station Area Plan)
www.forwarddallas.org/files/up/20060830/Westmoreland.pdf

Best Practices Coordination of Transit, Regional Transportation, Planning and Land Use

http://www.uwm.edu/Dept/CUTS//trb/conf/bestweb.htm

Calgary Transit, Transit Friendly Design Guide
http://www.calgarytransit.com/pdf/transit_friendly.pdf

Robert Cervero, Making Tyson's Corner Work
www.fairfaxcounty.gov/dpz/tysonscorner/cerveroapr2007.pdf

Noteworthy MPO Practices in Transportation-Land Use Planning Integration
http://www.ampo.org/assets/128_ampotranlanduserptfinal05.pdf

USGBC: LEED for Neighborhood Development
http://www.usgbc.org/DisplayPage.aspx?CMSPageID=148

2.1 GUIDELINE 2

Engage the Public Early with a Thorough Community Outreach Effort

principles

- Engage the public to build support for transit-friendly development
- Improve public understanding of transit and land use planning principles
- Attract new transit riders

recommendation

- Engage local groups including community development and housing advocacy groups to co-lead planning of station and transit node areas
- Ensure that the public is educated about goals and process through a community relations campaign.

context

It is important to tie the project outcomes to the community's own values in order align initiatives and increase the project's chances of success. Use a strategy of "outcomes-based" decision making.

measurement

- Involved stakeholders and project partners

more information

Transit Oriented Development Guidebook, City of Austin
Austin NPZ-2006 Transit-Oriented Development (TOD).pdf

Strategies and Actions for Supporting Transit Oriented Development; Bay Area Transit and Land Use Coalition
www.greatcommunities.org/local-efforts/strategies-and-actions

Fruitvale Transit Station BART
www.fhwa.dot.gov/environment/ejustice/case/case6.htm

Shanna O'Hare
Senior Transportation Planner
City of Oakland
Public Works, Design and Construction Services
250 Frank H. Ogawa Plaza
Oakland, CA 94612
(510) 238-6613

Oregon Metro: Public Involvement Policy for Transportation Planning
www.oregonmetro.gov/index.cfm/go/by.web/id=7715

Bay Area Rapid Transit's Use of Social Networking:
twitter.com/sfbart
sfbart.posterous.com/

2.1 GUIDELINE 3

Coordinate Modal Integration among Transit, Pedestrian, and Bicycle Routes to Enhance System Interconnectivity

principles

- Integrated modal functions
- Enhance system interconnection
- Public & private partnerships
- Enhance transit ridership by increasing ease of connections.

recommendation

- Integrate planning of traffic, pedestrian, bicycling, and various forms of transit into a single comprehensive planning function.
- Analyze transportation coordination on a range of scales from neighborhood, corridor, and regional planning.
- Develop performance-based station and transit node access strategies and design stations and transit nodes accordingly with special attention to a walkable urban design context.
- Coordinate with related transportation agencies or departments and develop a strategic approach to ongoing transportation planning such as an overall “vision plan” or cross-departmental offices for individual projects.
- Fund transit projects to include improvements beyond the footprint or ROW of the transit agency to ensure pedestrian connections within local area.

context

Modal integration is important because it supports continuity of experience for the transit user, encourages transit use, and encourages healthy lifestyles.

measurement

- Mode share and performance standards for station and transit node access
- Level of coordination between agencies responsible for planning of various modes

implementation

- Include walkability and bikeability analysis in all station

and transit node designs

- Plan for the provision of bicycle carrying capacity on transit

case studies

TriMet and the City of Gresham, in partnership with METRO (regional MPO) developed the ***Gresham Central Transit Center*** as multi-modal hub that also supports Gresham's revitalized downtown.

Gresham, with its historic downtown, is the fourth largest city in the state of Oregon. It is known for its vibrant pedestrian-oriented retail, civic, dining, and commercial space, and its neighborhoods. It is also the trailhead entrance to the Spring Water Trail which links to the Portland metropolitan region's network of bicycle and pedestrian paths.

The modes served at the Transit Center include:

- 8 Bus routes
- MAX Blue Line
- Bike routes: Spring Water Trail
- Parking Structure: 600 cars
- Ground Floor Retail: 4000 sq. ft.
- Art in central plaza
- Operator's Break Facility
- Bike Parking spaces: 4 racks, 4 lockers

Population served by the transit center (within 1.2 mile radius), 4500. Modal splits are 63/37 (light rail/bus).

Development since the opening of the transit center – 5,521,745 sq. ft. (27% increase – 45% commercial, 32% residential which is 98% mulit-family, 12% public including new City Hall).

Gresham has grown from 90,205 in 2000 to 98,025 in 2006. Future development plans include:

- Mixed use retail/commercial/housing (Gresham Central & Rockwood Station areas).
- "Lifestyle Commerical" higher end retail, restaurants, and offices
- Large increase in pedestrian-oriented residential – smaller lots, attached rowhouses, and public-oriented spaces/parks

This growth has also seen increasing concerns about safety and security which resulted in TriMet conducting the “Burnside Light Rail Station Access and Illumination” pilot project. The study utilized ‘Crime Prevention Through Environmental Design’ principles to install updates to the Transit Center. Efforts like this will encourage greater use of the Transit Center as a place for all transit users. Safe, well illuminated transit, parking, bicycle and pedestrian routes can activate streetscapes, and thereby support ‘Livable Communities’ development goals.

more information

New Jersey Transit Friendly Communities
www.njtransit.com/tm/tm_servlet.srv?hdnPageAction=TransitFriendlyTo

Ped to MAX Program; Gresham, Oregon
www.ntl.bts.gov/lib/1000/1100/1163/00778496.pdf

European Cyclists' Federation, Bikes and Trains: Provisions for Bicycles Made by the Railways of Western Europe, Copenhagen, Nov. 1992, p. 6.

CALTRAIN Bicycle Master Plan
www.caltrain.com/bicycle_master_plan.html

Octavia Boulevard, San Francisco; Cross-departmental project offices
www.sfgov.org/site/sfdpw_page.asp?id=32258

Mobil.Punkt Project (Integrative user experience); Bremen, Germany
www.isr.umich.edu/carss/projects/smart-enews/070317.html
verkehrsinfo.bremen.de/44.html?&L=1&locale=en

2.1 GUIDELINE 4

Optimize the Amount of Land Devoted to Parking

principles

- Innovative approach
- Full life cycle consideration
- Measurement
- Partnering

recommendation

Parking can take up a lot of land at transit stations. This land, when possible, can be better used for housing and other transit-oriented development. In other instances, parking lanes may be eliminated to provide room for transit, bicycles, or pedestrians.

- Use market analysis and education to develop 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 support of car sharing organizations.
- Where necessary, plan station and transit node areas to give private vehicles lower priority than pedestrians or remove parking from streets in order to optimize transit and pedestrian flow, scale, and quality of experience
- 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.
- When surface parking is provided and parking capacity must be maintained to ensure ridership, consider building parking structures and developing remaining land as high-density residential and other transit-oriented development.
- Ensure that station and transit node parking includes alternatives such as vanpool, carpool, and compact spaces.
- Consider pricing parking fees to make bus, bicycle, and

pedestrian access to stations and transit nodes more attractive.

Context

Quality of urban experience is related directly to the minimization of the automobile's impact on streets and land use.

While parking is an asset in initially encouraging ridership in lower density markets, the land used for parking ultimately has a better use in comprehensive land use.

measurement

- Motor vehicle ownership in station and transit node area vicinities
- Shared Parking Analysis
- Parking Management Plan
- Percentage of transit riders who drive to stations or transit nodes

implementation

- Parking Management Plan

case studies

Tri-Met Parking Management: Portland, Oregon's Tri-County Metropolitan (Tri-Met) Transportation District has implemented various parking management strategies around transit stations to minimize costs and support Transit Oriented Development (TOD). These include:

- Arranging Shared Parking with Park & Ride and other types of land uses, including apartments, churches, movie theaters, and government buildings near transit stations.
- Using lower minimum standard for the number of parking spaces required around transit stations.
- Allowing Park & Ride capacity near transit stations to be reduced if the land is used for Transit Oriented Development, thus allowing some of the car trips to access transit to be replaced by walk/bike trips.

(www.tri-met.org)

More Accurate Parking Requirements: The ***City of Vancouver*** is developing a more flexible approach to parking requirements for multi-family dwellings to support efficient transportation, smart growth, and affordable housing planning objectives. City staff has proposed a Sustainable Transportation Credit Program that allows developers more

flexible parking requirements based on their specific location and circumstances. The program is loosely based on the LEED™ Green building rating system. Developers receive credits for reducing the number of parking stalls, providing parking spaces for carshare vehicles, and providing annual transit passes to building occupants. (www.sfu.ca/~ssbc/Resources.htm)

Centralized Parking (USEPA, 2006): To encourage downtown development the ***Chattanooga Area Regional Transit Authority*** developed peripheral parking garages with free shuttle service. By constructing parking facilities at either end of the business district, the system intercepts commuters and visitors before they drive into the city center, reducing traffic problems. Free shuttle buses are financed through the garages' parking revenues. They depart from each garage every five minutes all day, every day, and pass within walking distance of most downtown destinations. The electric-powered shuttles transport approximately one million riders each year, making shuttle-served property attractive to businesses. Since 1992, when the shuttle service began, over $400 million has been invested in the downtown, including a major freshwater aquarium, over 100 retail shops and 60 restaurants.

"Paved Over: Surface Parking Lots or Opportunities for Tax-Generating, Sustainable Development?" evaluates the potential economic and social benefits if surface parking lots around rail transit stations were developed into mixed-use, pedestrian friendly, transit-oriented developments. The analysis concludes that such development could help to meet the region's growing demand for affordable, workforce, senior, and market rate housing near transit. The analysis further concludes that such development could provide a variety of benefits including increased tax revenues and reduced per capita vehicle travel. It was estimated that the parking lots in nine case studies could be developed as 1,188 new residential units and at least 167,000 square feet of new commercial space. (www.cnt.org/repository/PavedOver-Final.pdf)

Bus Rapid Transit in MTA- NYC Transit: After much study and community consultations, a Bus Rapid Transit (BRT) pilot/demonstration program was initiated in 2008. Along some routes parking lanes are and will be eliminated.

more information

Austin Parking Benefit District
www.ci.austin.tx.us/parkingdistrict/default.htm

Driving Urban Environments: Smart Growth Parking Best Practices
www.smartgrowth.state.md.us/pdf/Final%20Parking%20Paper.pdf

City of Ventura Parking Management Plan
www.cityofventura.net/.../resources/downtown/Ventura_FinalMobility%2BPkngMngmntPlan.04.06_Accepted.pdf

The Price of Parking on Great Streets:
www.planetizen.com/node/19150

Shoup, Donald, *The High Cost of Free Parking:* Planners Press, 2005.
myapa.planning.org/APAStore/Search/Default.aspx?p=1814
This is a comprehensive and entertaining book of the causes, costs, and problems created by free parking, and how to correct these distortions.

Victoria Transportation Policy Institute's website, includes for example "Parking Cost, Pricing , and Revenue Calculator"
www.vtpi.org/

BART Access Policy Methodology (Replacement Parking for Joint Development)
bart.gov/docs/planning/BART%20Access%20Policy%20Methodology.pdf

BART Parking Management Toolkit
bart.gov/docs/planning/BART_Parking_Management_Toolkit_2000.pdf

2.1 GUIDELINE 5

Develop or Coordinate an Agency Partnership for Transit Oriented Development and Mobility Enhanced Development

principles

- Innovative approach
- Measurement
- Partnering

recommendation

- Where applicable, transit agencies and partners may join forces with local efforts to revitalize urban communities and improve their livability through joint development projects and public/private partnerships
- Encourage revision of FTA guidelines on how federally funded land can be used for development in conjunction with the development of a transit project.
- Transit agencies may seek regulatory assistance or provide financial assistance for initial transit oriented development projects.
- Where opportunity for new community development exists, integrate appropriate mode of mobility with land use & community development.

context

Transit Oriented Development (TOD) offers the potential to boost transit ridership, increase walking activity, mitigate sprawl, accommodate growth, and create interesting places in communities with existing transit systems.

Mobility Enhanced Development (MED) offers potential to optimize transportation distance and mode choice as part of land use policy.

Transit agencies encounter problems with how they can use federal monies. Monies used to purchase property for transit improvements are limited in their usage for development.

measurement

- Corridor-based performance measures to quantify minimum levels of development around transit stations or transit nodes
- Transportation distance and mode optimization measures

case studies

Los Angeles Metro Joint Development (JD)/Transit Oriented Development (TOD): At Metro JD projects the public has experienced increased comfort and safety when the Station Plaza and adjacent Metro properties were developed into the TOD/JD Projects. Prime examples are:

- Hollywood/Highland Station(Academy Center, major retail, entertainment)
- Hollywood/Western Station (60 affordable housing units and mixed use)
- Wilshire/Vermont Station (449 residential units, 90 affordable, mixed use)
- Wilshire/Western Station (22-story, 186 residences/penthouses 40,000 SF Retail)
- Hollywood/Vine Station (W Hotel, Condos, Apartments, Mixed Use $600 million in const)

Initially when the Red Line Stations were opened, the plaza area and Metro adjacent properties were underutilized and there were maintenance and safety issues. However Metro's partnership with CRA, private developers, the City and stakeholders creating transit supportive land use policies accomplished the high quality Joint Developments mentioned above. The communities, transit users, and retails adjacent to Metro JD are benefiting from Enhanced Safety/Comfort, increased property values which also results in more income to the City.
(www.metro.net/projects_programs/joint_development.htm)

more information

MTC Transit Oriented Development Policy (San Francisco Bay Area)
www.mtc.ca.gov/planning/smart_growth/tod/index.htm

Financing Transit-Oriented Development in the San Francisco Bay Area – Policy Options and Strategies prepared by Reconnecting America
www.reconnectingamerica.org/public/show/200811mtcfinancingtodinsfbav2

Translink: Vancouver Skytrain Line – Transit Villages
www.translink.bc.ca/Plans_Projects/Urban_Showcase/transit_villages/broadway_commercial.asp

Rosslyn-Ballston Corridor
www.epa.gov/smartgrowth/arlington.htm

Kenosha-Racine-Milwaukee Commuter Rail, *Transit Oriented Development Technical Report*
www.sewrpc.org/KRMonline/reports.shtm

Transit Cooperative Research Program: *TCRP Report 102: Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects.*
onlinepubs.trb.org/Onlinepubs/tcrp/tcrp_rpt_102.pdf

2.1 GUIDELINE 6

Scale Transit Appropriately

principles

- Transit integrated with community
- Station or transit node scale appropriate to urban context
- Transit project supports or creates adjacent connections
- Transit's civic improvements leverage local commerce and activities

recommendation

Scale and locate transit so that it integrates into the fabric of a community:

- The finer the urban grain, the more measured and integrated the transit solution must be. 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 space.
- 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 that is desired.
- Fund Transit Projects to include improvements beyond the footprint or ROW of the transit agency to ensure pedestrian connections within local jurisdiction ROW.
- Design public spaces along the systems to encourage social interaction. Use transportation planning, operations, and marketing to integrate public transportation more comprehensively with people's lives. This reduces dependency on automobiles and increases quality of life.
- Provide easy access to dining, shopping, landmarks, special attractions, unique neighborhoods, and everyday services.
- Make public transport easy to use for visitors and for sightseeing.

Context

Make the experience of public transport use safe, convenient, affordable, and integrated with housing, office buildings, entertainment, and services for everyday commuters.

Many transit projects limit their improvements to the agency right of way, with necessary pedestrian improvements to local uses being ignored. Opportunities for connections to local uses are many times lost, or take years to complete while waiting for funding.

measurement

- Density and height of development in station or transit node area and surrounding neighborhood.
- Mode of access to transit station or transit node by riders (walking, driving, etc)

implementation

- Percent funding from project budget related to local jurisdiction pedestrian improvements.
- Matching funding from local jurisdictions related to local pedestrian improvements.

case studies

Portland, Oregon, Tri-Met MAX 'Yellow Line' used its 5.8 miles to transform a former state highway into a pedestrian scaled boulevard. Surface light rail improvements that responded to local neighborhood goals included:

- Improved pedestrian focused intersections.
- Improved streetscape landscaping.
- On-street parking to support neighborhood commerce.
- Bicycle lanes for local and regional connectivity.
- In street platforms fit within existing right-of-way, adjacent platforms to leverage neighborhood development goals.
- Art program reinforce neighborhood identity and culture
- Transit ancillary buildings fit neighborhood scale and context

Yellow Line transit station elements were designed to fit within various neighborhood characteristics: Rose Quarter entertainment district, industrial Lower Albina, Overlook Park and medical center, residential Arbor Lodge, and historic

Kenton. Using ‘Elements of Continuity’ established and reinforced the regional transit system. These elements included consistent signage, platform materials, and shelter design. ‘Element of Distinction’ helped reinforce individual neighborhood qualities and context scales. These elements included vertical art elements, landscaping, and streetscape materials.

more information

Transit Cooperative Research Program: *TCRP Report R-123: Understanding How Individuals Make Travel and Location Decisions: Implications for Public Transportation*
onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_123.pdf

2.1 GUIDELINE 7

Use Life-Cycle Analysis to Address Grade Separation

principles

- Maximized speed and efficiency for transit and increased efficiency for other modes of transportation
- Decreased noise, emissions and vibration

recommendation

When possible and when required (i.e. due to electric third rail), utilize grade separated solutions thereby maximizing speed, efficiency, and capacity of the transit system.

- Integrate the entrances of grade separated stations (and support spaces) into adjacent developments rather than trying to locate them in the street right of way.
- Consider short and long term impacts to adjacent land uses along alignment.
- Plan alignment to minimize, to the extent possible, the disruptive effects of construction such as cut and fill operations.

Grade separated transit systems refer to systems that are constructed either above-grade (i.e. using elevated guideways) or below-grade (i.e. via tunnels). Grade separation can also be achieved when transit is in a dedicated right-of-way at-grade and either overpasses or underpasses are constructed for intersecting vehicular and pedestrian routes. Depending on terrain and existing infrastructure, grade separated transit systems may utilize a combination of elevated guideways, subways, and at-grade segments.

In the case of transit systems using an electric third rail, grade separation is required for safety.

The benefits of grade separation are many:

- Increased speed and efficiency
- Reduced congestion for both the rapid transit system and other modes of transportation at street level
- Increased passenger and pedestrian safety
- Decreased noise, emissions, and vibration at street

level

- In areas of heavy snow fall, subways remove transit from the obstruction of heavy snows.
- Option of utilizing electric third rail systems and other technologies which require separation to protect the public.

context

Transit that exists in dedicated rights of way facilitates safe, convenient and attractive connections into the fabric of the communities it serves. Grade separated options such as elevated or underground systems require special focus on short and long term impacts of alignments on adjacent land-uses.

measurement

- Efficiency of system (people per hour) for grade-separated mode vs. at-grade modes

case studies

The ***San Francisco Bay Area Rapid Transit (BART)*** was conceived in the period 1957-1962 as a grade-separated rapid transit system in order to maximize speed and ease congestion throughout the region. Grade separation was used as a strategic decision early in the planning process in order to build a first-rate transit system.

From agency's website "Electric trains would run on grade-separated right-of-ways, reaching maximum speeds of 75-80 mph, averaging perhaps 45 mph, including station stops. Advanced transit cars, with sophisticated suspensions, braking and propulsion systems, and luxurious interiors, would be strong competition to "King Car" in the Bay Area. Stations would be pleasant, conveniently located, and striking architectural enhancements to their respective on-line communities."

The capital cost of grade separated systems can be considerably higher than that of at-grade systems due to the increased amount of materials, labor, and civil works associated with building a structure to house the rail tracks. This can be partially offset by the increased efficiency in the grade-separated transit system, i.e. the ability to move greater numbers of passengers in a shorter period of time than would be possible at-grade. In addition, the reduction in interface with street activities, particularly vehicle movement, traffic signals, pedestrian crossings, etc. results in efficiency for both the street and the transit system. At-grade systems are recommended for

use outside dense areas, since some grade separated systems, particularly when built on an embankment or in a recessed cut, create a physical barrier that hinders flow of people and vehicles across their path.

Many early rapid transit systems chose below-grade separation (***London, New York, Paris***) as the preferred means of transit system design, despite the cost and disruption associated with the initial construction.

Other cities with early well-known above-grade systems include ***Chicago's Elevated*** system. More recently, cities around the world have chosen elevated systems, including ***London's Docklands Light Railway*** and the ***Vancouver Skytrain***.

Paris Metro construction
wapedia.mobi/en/Rapid_transit

more information

Transit Cooperative Research Program, *TCRP Report 116: Guidebook for Evaluating, Selecting, and Implementing Suburban Transit Services*
onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_116.pdf

materials

TBD

energy

Intent & Scope

This section provides guidelines aimed at leveraging alignment and route planning to minimize the overall energy consumption of the transit system.

guidelines

Three guidelines are provided for Energy under System Route, Transit Mode & Node, and are discussed in more detail in the following subsections:

guideline 1: Partner with Local Power Utility

guideline 2: Consider Energy Consumption when Choosing Mode

guideline 3: Design Alignment to Optimize Energy Use

2.3 GUIDELINE 1

Partner with Local Power Utility

recommendation

- Partner with utility companies in the transmission and microgeneration of electricity because transit organizations do not normally have expertise in these areas.
- Consider if transit system's right-of-way has opportunities for alternative energy generation such as solar or wind.
- Other renewable energy sources worth investigating at the outset of projects include: ground source heating or cooling and cogeneration.

context

Most local power companies include green power in their supply mix. Additional green power can be purchased at a premium, which in turn is used by the supply company to develop green electricity production for the grid. The energy demands of a transit system are significant. As the generation of electricity is not typically part of its core business, the partnering of a transit system with a local power supplier may be appropriate in order to efficiently develop renewable energy sources.

measurement

- Investment dollars in alternative energy projects
- Percentage renewable energy use
- Total carbon footprint of system based on source energy

case studies

Systems Power Reduction: NYC Transit began surveying depots, yards and other facilities in the 1990s in collaboration with the New York Power Authority (State owned, energy provided to the states agencies) to reduce power in heating, ventilation and air-conditioning systems. Agency completed more than 45 projects between 1993 and 2007 and now saves close to 50 megawatt hours of electricity annually – that's upwards of 30 tons of CO2 emissions avoided every year.

more information

Calgary Transit Ride the Wind program
www.calgarytransit.com/environment/ride_d_wind.html

Plug in Power Austin Texas; Austin Energy

LA Metro; Solar Power installations

2.3 GUIDELINE 2

Consider Energy Consumption when Choosing Mode

recommendation

Optimize energy and resources by achieving best fit between the transit route and the mode of transit chosen.

- Consider energy in 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.
- Match the size and speed of vehicle to the neighborhood being served.
- Match the type of vehicle to the geography of the neighborhood being served. Steep grades require a different type of transit vehicle than do routes that are moderate in topography. This will affect the type of energy required (electric, diesel, hybrid, etc.). Fleets may be comprised of a variety of vehicles to suit varying local terrain conditions and size of ridership.
- Consider efficiency of route in terms of speed and energy consumption. Grade separated transit systems will reduce the amount of energy per passenger mile traveled by reducing idling time and permitting travel at constant optimal speeds. This improved energy efficiency will partially offset higher initial capital costs of construction.
- Take note of new model improvements, schedule review and evaluation of current models and model improvements already under way.

context

Optimize energy and resources by achieving best fit between the transit route and the mode of transit chosen.

measurement

- Energy consumption per passenger mile
- Focus on energy consumption per passenger miles and avoid cutting back service based on simple total energy use of the system.

more information

Transit Cooperative Research Program: TCRP Report S-41:

The Use of Small Buses in Transit Services
onlinepubs.trb.org/Onlinepubs/tcrp/tsyn41.pdf

2.3 GUIDELINE 3

Design Alignment to Optimize Energy Use

recommendation

Identify opportunities to optimize energy use through fundamental decisions about routing, alignment, and track engineering.

- Seek out and leverage the specific opportunities for energy optimization based on the climate/geographic condition of the transit system.
- Optimally horizontal alignment is straight and when spirals or curves are introduced, the radii should be large enough to minimize braking and accelerating.
- Consider the advantages of a rising and falling vertical alignment to aid acceleration and braking. Optimize energy consumption through refinements in vertical alignment. Where possible, slope tracks up approaching a station and down for departing a station, allowing gravity to naturally decelerate/accelerate the transit vehicle.
- Seek synergy in the design of tunnels through potential use of “found” geothermal energy. (See “More Information” below.)
- Optimize spacing of wayside energy storage devices and substations for energy efficiency.
- Grade separate transit where possible to increase efficiency of systems. This requires a greater up-front investment of energy and materials for construction but results in considerable savings in time, energy, and quality of transit service.
- Where practical, reduce energy through minimizing height of elevated structures and depth of underground structures. This leads to reduced embodied energy by using less material in construction, reduces the energy required for deep excavation and hauling of fill, and requires fewer and shorter vertical circulation devices such as elevators and escalators.

measurement

- Energy as life cycle cost

more information

Tunnels for the Copenhagen Metro. COWI. Retrieved 04 July 2007.

www.cowi.com/cowi/en/menu/projects/transport/tunnels/boredrockandnatmtunnels/

US Department of Energy, Energy Efficiency and Renewable Energy (updated 07 Dec 2006). Geothermal Heat Pumps. Retrieved 05 July 2007.
www1.eere.energy.gov/geothermal/heatpumps.html

International Tunnelling and Underground Space Association (2003-2007). 5 – The Metro Vienna PA9 Line 2. Retrieved 25 June 2007.
www.uta-aites.org/cms/1069.html

Unterberger, W., Hofinger, H., Grunstaudl, T., Adam, D., & Markiewicz, R. (31 Dec 2004). Utilization of Tunnels as Sources of Ground Heat and Cooling – Practical Applications in Austria. Retrieved 04 July 2007.
www.ic-group.org/index.php?id=23&lang=en&from=10

NYC MTA, “MTA NYC Transit Contributions to Sustainability,” Capital Program Management, MTA 3/2007

VIA Architecture, U-Link Sound Transit Sustainability Report, 8/2007

Portland TriMet “A Natural Step Case Study”

TriMet Sustainability Policy

Geothermal potential of railway tunnels in London
www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V34-4KYXHSK-1&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_version=1&_urlVersion=0&_userid=10&md5=b64cdebe79ce688b71841d2cb0563610

2.4 SYSTEM ROUTE, TRANSIT MODE & NODE

ambient environment & health

Intent & Scope

This section provides guidelines aimed at improving overall public health through appropriate transit planning and promotion.

Reference Standards

LEED© Neighborhood Development: LEED ND provides guidance for projects to protect and enhance the overall health, natural environment, and quality of life of communities. The CDC's review of LEED ND determined that several of the Smart Location & Linkage (SLL) and Neighborhood Pattern & Design (NPD) prerequisites and credits support tangible health benefits such as:[3]

- Reduced risk of heart disease, obesity, and hypertension
- Reduced risk of asthma and other respiratory diseases via reduced air pollution
- Reduced risk of vehicular crash related injury
- Increased social connection and sense of community
- Improved mental health via reduced commute times

Draft LEED ND Guidelines can be found at:
www.usgbc.org/ShowFile.aspx?DocumentID=5275

guidelines

One guideline is provided for Ambient Environment & Health under System Route, Transit Mode & Node, and is discussed in more detail in the following subsections:

guideline 1: Promote Environmentally Friendly and Healthy Modes of Transportation

3 www.usgbc.org/ShowFile.aspx?DocumentID=5895

2.4 GUIDELINE 1

Promote Environmentally Friendly and Healthy Modes of Transportation

recommendation

- Design and locate stations/terminals/stops to promote environmentally friendly and health-promoting modes of transport, such as walking and bicycling.
  - Provide bike racks and bike lockers, and
  - Provide for bike repair and rental businesses.
- 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.
- Document efforts to better accommodate and encourage walking and biking. Share documentation with stakeholders on a regular, planned basis.
- Consider developing bike and pedestrian paths along alignment.
- Promote transit through advertising the benefits of a healthier, community-connected lifestyle. Use signs, commercials, and other media.

context

Encourage individuals to choose transit over other modes of transportation. Transit should be a positive, stress free experience. Riders should feel safe in facilities and on vehicles and have easy access to the transit system. Riders should be fully aware of the advantages the transit experience offers compared to other modes, such as promoting a more active, healthy lifestyle. Location and design of facilities and systems should encourage walking, biking, and other environmentally preferable, healthy modes of transportation.

When station or transit node access is made easy for pedestrians and cyclists, it encourages healthy lifestyles with corresponding reductions of illnesses such as diabetes.

Increased public awareness of the more active, healthy lifestyle associated with riding transit may increase ridership, offsetting

driving.

measurement

- ***Target:*** Set station or transit node and system specific targets.
  - Establish criteria for number of bike racks and lockers at each station or transit node.
  - Each bus to hold at least 2 bikes
  - At least 10% of riders feel they could safely bike or walk to transit, increase percentage when possible
- ***Indicator:***
  - Document bike rack and locker usage at each station. Add more where warranted.
  - Bike racks per station
  - Pedestrian and bicycle accommodations into every new project (Y/N)
  - Survey riders arriving by walking/bike/other pedestrian mode

case studies

San Francisco Bay Area Rapid Transit (BART) has undertaken various efforts to communicate the environmental benefits of transit to current and potential riders. The trip planner on BART's website provides riders with a figure for the amount of carbon dioxide (CO_2) emissions that they can "save" by taking BART instead of driving, for any trip that they look up on the trip planner. BART also has an onboard ad campaign that highlights the environmental benefits of riding transit, such as decreased air pollution, and "thanks" riders for their contribution to these benefits. (www.bart.gov/guide/carbon.aspx)

Caltrain, a commuter rail line that links San Francisco and San Jose in California's Bay Area, is a leader in providing onboard bicycle capacity. Caltrain first allowed bikes aboard trains in 1992 with a pilot program that allowed four bikes on a few trains. Since then, onboard capacity has gradually increased, with Caltrain's Board of Directors recently approving a plan to increase capacity by 27%. Under the plan, each train will have space for either 24 or 40 bicycles, depending on the type of train. Future goals include providing 2 bike-only cars on peak period trains. Caltrain encourages an active dialogue with the bicycle community, including a formal bicycle advisory committee.

The ***Metropolitan Washington Council of Governments*** "Guaranteed Ride Home" program supports the convenience of transit by offering regular riders a guaranteed taxi ride home in case of a personal emergency, such as personal illness of a sick child. Transit riders who register with the program can use this service up to four times a year at no cost. (www.mwcog.org/commuter2/commuter/grh/index.html)

emissions & pollution reduction

Intent & Scope

This section provides guidelines aimed at reducing emissions and pollution generated by transit systems, and offsetting potential emissions and pollution by others through the provision of efficient transit service.

guidelines

One guideline is provided for Emissions and Pollution Reduction under System Route, Transit Mode & Node, and is discussed in more detail in the following subsections:

guideline 1: Plan to minimize noise and vibration

2.5 GUIDELINE 1

Plan to Minimize Noise and Vibration

recommendation

Consider potential for noise and vibration reduction through alignment planning principles:

- Grade separate transit alignments where feasible in order to reduce impacts of transit at 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.
- 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.
- Optimize frequency and location of bus stops to minimize impact of noise and emissions at street level.
- Utilize technology to minimize noise and vibration such as through vehicle design and use of resilient ties and pads.
- Consider underground alignment as one means of helping control noise and vibration near sensitive land uses such as hospitals and residences.

context

Support quality of environment along the transit corridor through design measures aimed at reduction of noise and vibration.

measurement

- Ambient air quality
- Existing ambient noise
- Traffic noise

implementation

- Identify sensitive land uses along alignment and possible mitigation measures.
- Identify noise and vibration measures to be built into system, i.e. vehicle design, resilient track fasteners..

more information

Transit Cooperative Research Program: *TCRP Report RRD-19: Wheel/Rail Noise Mitigation*

onlinepubs.trb.org/Onlinepubs/tcrp/tcrp_rrd_19.pdf

Transit Cooperative Research Program: *TCRP Report 23: Wheel/Rail Noise Control Manual* onlinepubs.trb.org/Onlinepubs/tcrp/tcrp_rpt_23.pdf

Federal Transit Administration, *Transit Noise and Vibration Impact Assessment,* May 2006 www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf

3 infrastructure & facilities

introduction

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

The following guidelines are provided for this section, Infrastructure & Facilities:

3.1 System Planning and Land Use (N/A)

3.2 Materials

Guideline 1: Mitigate the Embodied Energy contained in structures for transit use

Guideline 2: Ensure Appropriate Material Use

Guideline 3: Design for Long Service Life and Durability

Guideline 4: Design for Flexibility

Guideline 5: Use Recycled Materials

Guideline 6: Design for Low Maintenance

Guideline 7: Incorporate Innovative Sustainable Construction Practices

3.3 Energy

Guideline 1: Design for Energy Efficiency

Guideline 2: Partner with Local Power Utility

Guideline 3: Optimize Efficiency of Rail Systems

Guideline 4: Minimize Transmission Losses

Guideline 5: Consider Innovative Approaches to Energy Usage

3.4 Ambient Environment & Health

Guideline 1: Provide Inviting Spaces/Art/Entertainment

Guideline 2: Enhance Wayfinding

Guideline 3: Provide Weather Protection

Guideline 4: Maximize Comfort and Safety

3.5 Emissions & Pollution Reduction

Guideline 1: Mitigate Hazardous Materials and Preserve Air Quality

Guideline 2: Design for Water Efficiency and Re-use

Guideline 3: Establish Green House Gas Monitoring on Facilities

Guideline 4: Implement Waste Management and Recycling

Guideline 5: Control Erosion

3.1 INFRASTRUCTURE & FACILITIES

systems planning, land use & site design

See Section 2.

materials

Intent & Scope

This section provides guidelines for improving the sustainability of material elements unique to transit infrastructure and facilities. Materials traditionally considered environmentally preferable are not always best for transit systems, as detailed in the guidelines below.

A broad definition of materials is taken to include material selection and design and construction of physical structures. Three classifications of materials are used:

- ***Components:*** Basic material elements,
- ***Assemblies:*** Components grouped together, and
- ***Systems:*** Groups of materials arranged to perform a complex function.

Reference Standards

As applicable, best practices for sustainability created by other industries are encouraged. The following standards contain valuable information for addressing material elements of transit infrastructure and facilities. Their careful adoption, as applicable, will aid in fully addressing sustainability.

U.S. Green Building Council's Leadership in Energy & Environmental Design (LEED) is a rating system for sustainable building. Consider applying LEED standards for conventional buildings, such as offices and maintenance shops. (www.usgbc.org/leed/)

Green Building Initiative's Green Globe is a green building guidance and assessment program. (www.thegbi.org/green-globes-tools/)

International Initiative for a Sustainable Build Environment's SBTool 07 is a toolkit for assessing the sustainability of traditional buildings. (www.iisbe.org/iisbe/sbc2k8/sbc2k8-dwn.htm)

guidelines

Seven guidelines are provided for Materials under Infrastructure & Facilities, and are discussed in more detail in the following subsections:

guideline 1: Mitigate the Embodied Energy contained in structures for transit use

guideline 2: Ensure Appropriate Material Use

guideline 3: Design for Long Service Life and Durability

guideline 4: Design for Flexibility

guideline 5: Use Recycled Materials

guideline 6: Design for Low Maintenance

guideline 7: Incorporate Innovative Sustainable Construction Practices

National Institute of Standards and Technology Building for Economic and Environmental Sustainability (BEES) measures the environmental performance of building products by using the environmental life-cycle assessment approach specified in ISO 14000 standards. (www.bfrl.nist.gov/oae/software/bees/)

The ***U.S. EPA's Environmentally Preferred Purchasing Program (EPP)*** provides a set of guiding principles for the procurement of most products from supplies and services to buildings. The EPP guidelines were adopted by the Federal Government via Executive Order 13423 – Strengthening Federal Environmental, Energy, and Transportation Management (2007). The full text on the EPA's Final Guidance on Environmentally Preferable Purchasing can be found at: (www.epa.gov/opptintr/epp/pubs/guidance/finalguidance.htm)

3.2 GUIDELINE 1

Mitigate the Embodied Energy Contained in Structures for Transit Use

recommendation

- Design for durability and very long service life
- Maximize use of existing infrastructure and facilities when choosing transit alignments.
- Consider the use of shared facilities and resources when feasible.
- Develop a checklist of construction practices that are either environmentally friendly, or not environmentally friendly, that can be utilized during various project phases, i.e., during planning, it could be determined whether a site will require large quantities of cut and fill. A level site, with good structural soils, will require less environmental impact to build on.

context

Transit systems must be able to maximize the investment in the system in order to carry out their function. Durability and efficiency make a transit system viable.

measurement

- GHG emissions measures
- LCA

3.2 GUIDELINE 2

Ensure Appropriate Material

recommendation

- Ensure quality of experience for the transit user by investing in the correct materials to suit the transit mode application.
  - Where possible, use “low embodied” energy material such as local or recycled materials with low transportation costs.
  - 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.
- Ensure that materials used in the construction of transit structures are scaled and detailed appropriately for urban communities, e.g. detailed for weather resistance, provide visual interest at pedestrian level, permit passage of light.

measurement

- Life cycle costing (LCC) and life cycle analysis (LCA) of materials specified for transit construction
- Measurements outlined in referenced standards, as appropriate

more information

Construction Specification Institute “Green Format”

3.2 GUIDELINE 3

Service Life and Durability

recommendation

- Select materials with environmentally and economically superior service lives when designing core infrastructure.

context

The need for long service life makes transit infrastructure unique. Bridges, tunnels, and tubes are often designed to last well over a century and must be supported by adequate components and assemblies. When weighing environmental tradeoffs in material selection for core infrastructure, service life and durability should be given paramount importance.

The environmental impacts of initial builds and repair work are tremendous, including fabricating and transporting materials, construction equipment exhaust, and congestion from diverted traffic routes. Materials traditionally considered environmentally preferable will therefore not always be best for core transit infrastructure. For example, if use of certain recycled materials reduces the service life of a bridge, then larger picture environmental and economic costs will overrule the use such materials.

Goals:

- Increase comprehension of the extensive environmental benefits that result from a longer service lives and higher durability. List, quantify, and calculate.
- Reduce the frequency of core infrastructure repair and replacement by fully considering service life and durability in material selection. Measure, monitor.

measurement

- Is service life and durability used as heavily weighted criteria when designing core infrastructure? (Yes/No)
- Promote within planning phase of projects life cycle costs comparisons
- LCA

more information

BART Tube – service life – connectors need longer service life so tube remains in service.

3.2 GUIDELINE 4

Design for Flexibility

recommendation

- Design for flexibility, including system expansion, increases in ridership, and alternative uses of supporting facilities.

context

Minimize the environmental and economic consequences of future construction by designing for flexibility. Financial costs of securing land or providing tunnel space for future use are far less if done during the initial build. A small percentage increase in capital costs today can offset far greater future costs. Major environmental benefits are also achieved by reducing the need for future modifications.

Goals:

- Incorporate system flexibility into planning and design processes
- Reduce costs and environmental impacts by adjusting to changes in ridership and facility use with minimal transit disruption, community displacement, and construction

measurement

- Is ease of system expansion incorporated into designs? (Yes/No)
- Are ridership estimates projected out at least X years? Are means to address these estimates incorporated into initial designs? (Yes/No)
- Is the methodology used to create ridership estimates reviewed and updated periodically, to make the best use of new technologies? (Yes/No)
- When designing supporting facilities, are possible alternative uses considered? (Yes/No)
- LCA

case studies

The ***Elati Maintenance Facility*** was designed to handle ***Denver Regional Transportation District's*** new 19.1-mile Southeast Corridor Light Rail storage and maintenance needs. The facility opened in early 2006, prior to the Southeast Corridor's opening on November 17 of that year. Subsequently,

part of the FasTracks program was to include a new Light Rail maintenance facility along the Right-of-way of the West Corridor, currently under construction.

At the beginning of the planning process, RTD wisely secured additional land for expansion of the Elati Maintenance facility. In the past four years rising prices for commodities such as steel, copper and concrete has affected the budget for the FasTracks Program. In the last year alone, RTD saw record ridership numbers, but tax receipts are not meeting projections. Consequently, in lieu of building an entirely new maintenance facility along the West Corridor line, RTD chose to enlarge the Elati Maintenance Facility. Fortunately, the Central location of the Elati facility allows quick and more efficient dispatch of additional rail cars to all points of the system to meet unexpected and special event passenger demand needs.

Due to the flexibility afforded by the land available for expansion at the Elati Maintenance Facility, RTD was able to realize environmental and cost savings benefits including use of less land by expansion rather than a new facility.

In addition, RTD has utilized sustainable construction practices through use of recycled materials for track and ballast. The Elati Maintenance facility is eligible for LEED-EB (Existing Building, Operations and Maintenance) Certification and RTD is pursuing this certification.

3.2 GUIDELINE 5

Recycled Materials

principles

- Innovative approach
- Use of recycled materials
- Full life cycle consideration

recommendation

- Incorporate recycled materials into transit projects when transit-specific requirements are met – longevity, durability, low-maintenance, etc. Favor post-consumer recycled content.

context

Numerous transit projects have reduced costs by incorporating recycled materials into project designs without compromising service life, durability, or quality of service.

Use of recycled materials offsets the energy-intensive process of fabricating new materials and reduces the amount of waste entering landfills. Working with research institutions, transit agencies can maximize environmental benefits by targeting materials that pose particular environmental challenges when abandoned, such as tires.

Transit has a unique opportunity to make use of recycled materials due to its large size and repetitive nature. For example, rail ties made from recycled plastic are used repeatedly for hundreds of miles in the San Francisco Bay Area. Fences provide another opportunity for repetitive, large-scale use of recycled components. High demand for materials provides researchers and investors with an incentive to work with the transit industry to develop high-performing recycled materials.

Use of recycled materials presents ‘win-win’ opportunities for partnering with research institutions, government agencies and environmental organizations. Use of recycled materials may make a project more economically viable by lowering costs. At the same time, there are numerous environmental benefits in line with the missions of potential project partners. See Section Two for details on partnering.

Goals:

- Increase awareness of the feasibility, environmental, and economic benefits of incorporating recycled materials into transit projects
- Work sessions, technical review, inter-agency communication
- Maximize use of recycled materials that support high quality transit systems.

measurement

- Is recycled content an evaluation criterion when comparing materials? (Yes/No)
- Checklist
- What percentage of annual projects incorporate recycled materials? Set goal and raise percentage annually.
- LCA

case studies

Recycled Content in Construction Materials: MTA NYC Transit requires use of coal combustion fly ash, available from the electric utility industry, in thick concrete in its master specification for all capital projects. Fly ash can replace, in part, an amount (up to 15%) of commercial cement in preparing the concrete mix. This takes the fly ash out of the waste stream and reduces the use of virgin Portland cement.

Recycled Plastic Rail Ties: San Francisco Bay Area Rapid Transit (BART) is swapping out worn wooden railroad ties with plastic ones made out of recycled grocery bags, milk bottles and old car tires. Plastic ties are stronger, lasting twice as long and are three times cleaner to make.

The project was initiated in November 2005 by agency's Track Maintenance team. Agency has replaced roughly 400 wooden railroad ties with ties made of plastic recycled material – that equates to 1.1 million grocery bags, 246,400 plastic bottles and 1200 tires.

Plastic ties are environmentally preferable:

- Wooden ties are soaked in creosote, linked to many environmental and health problems.
- Use of recycled materials greatly reduces total energy needed to create rail ties
- Diverts plastics from landfills

- Reduces consumption of forests
- In the end, the overall life cycle costs of plastic ties are much less because of their lifespan. Initially, plastic ties cost about the same as premium quality wood ties.

3.2 GUIDELINE 6

Low Maintenance

recommendation

- Choose materials that are easily maintainable for transit stations, transit nodes, terminals, stops, and supporting facilities.

context

Maintenance directly impacts environmental and economic sustainability. Use of cleaning products, water, electricity, and other inputs required for maintenance work should be minimized to the lowest level that allows for high quality transit service. Materials selection also directly impacts costs, including associated labor hours and quantities of maintenance materials, such as (example of common repair inputs from rail, bus, ferry).

When selecting materials, consider environmental impacts and financial costs from expected maintenance work. When possible, use actual performance data from material use.

Goals:

- Improve knowledge of the actual costs associated with material selection
- Reduce costs and environmental impacts by selecting low-maintenance materials

measurement

- Are environmental impacts of expected maintenance work considered in selecting materials? (Yes/No)
- Are economic impacts of expected maintenance work considered in selecting materials? (Yes/No)
- Is there a “feedback system” in place to track actual performance data from material use? (Yes/No)
- LCA

case studies

Installation of Solar powered compacting trash receptacles: Metropolitan Atlanta’s MARTA has embarked upon a pilot program to reduce the quantity of litter at remote

bus stop sites and reduce the trip frequency for trash pickup. This pilot project will also use a sustainable product.

Agency chose a Solar powered compacting trash receptacle, made by the BigBelly corporation. This receptacle is capable of reducing trash volume by up to 5 times by compacting the trash after each use. The compactor works via a solar panel on the top of the unit, charging an enclosed battery, thus requiring no external electrical service. The unit is about the size of a mailbox and is made partially of recycled materials.

This project was initiated in the summer of 2008 by agency's Facilities Maintenance group. Three sites were selected for the based on a number of criteria including: quantity of trash; distance from the home office, and visibility. These sites generally required daily trips for trash removal. Prior to installation, the travel distance, the time taken, and the amount of gas used were measured for each site. Since installation, weekly services of the units has been monitored.

The installation of these three units has reduced the amount of miles driving to collect the trash each week by approximately 150 miles; reducing labor costs, fuel costs, vehicle depreciation, carbon footprint, and helping with a cleaner environment, not only with the CO2 emissions, but with the litter problem.

Principles:

- Innovative approach
- Use of sustainable materials
- Renewable energy
- Measurement
- Reduced labor cost
- Reduced energy consumption

Refer to the spreadsheet for return on investment and environmental benefits at the end of these Guidelines.

more information

Examples of transit specific materials that have similar function but varying maintenance requirements. Such as stainless steel.

3.2 GUIDELINE 7

Innovative Sustainable Construction Practices

recommendation

- Seek local feedback from construction organizations and local construction firms
- Institute prefabricated components unique to transit in your specifications
- Get more information on local regulations to clarify opportunities for innovative construction practices
- Refer to LEED documentation for what should be done during construction
- When excavating, explore opportunities to utilize excavated materials on-site instead of hauling away.

context

Advanced and innovative construction methods have many benefits. They can reduce the duration of construction activities, improve project quality, minimize site impacts to neighboring properties and protect community health.

Rather than systematically incorporating traditional construction methods, investigate other options – especially options that have proven successful at other transit agencies.

Goals:

- Increase awareness of innovative construction methods utilized at other transit agencies. Improve knowledge of suitability, benefits, and risks of these practices.
- Reduce environmental and economic costs from site construction by utilizing innovative practices.

measurement

- Does your agency have a system for exploring and evaluating innovative construction practices? (Yes/No) (This where the previously mentioned checklist may be applicable.)
- LCA

more information

Prefabricated, modularity, off-site fabrication - Better accuracy, speed, quality – BART to provide example

energy

Intent & Scope

This section provides guidelines for improving the energy efficiency of infrastructure and facilities that are unique to transit. When appropriate, the guidelines are developed to address specific modes, including bus, ferry, and rail.

Reference Standards

For facility energy efficiency, the most relevant reference standard is ASHRAE 90.1. ASHRAE 90.1 is the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. energy standard for buildings. It provides minimum requirements for the energy-efficient design of buildings, and serves as the professional "standard of care" by ASHRAE consensus. Code that meets or exceeds the requirements of ASHRAE 90.1-2004 has been adopted in most states. ASHRAE 90.1-2007 is the most recent update, and it used to qualify for energy efficiency performance credits in the latest version of LEED.

Information on state energy codes can be found at: www.energycodes.gov/

Information on ASHRAE 90.1 can be found at: www.ashrae.org/

guidelines

Five guidelines are provided for Energy under Infrastructure & Facilities, and are discussed in more detail in the following subsections:

guideline 1: Design for Energy Efficiency

guideline 2: Partner with Local Power Utility

guideline 3: Optimize Efficiency of Rail Systems

guideline 4: Minimize Transmission Losses

guideline 5: Consider Innovative Approaches to Energy Usage

3.3 GUIDELINE 1

Design for Energy Efficiency

recommendation

- Facilities should be planned to reduce energy consumption during the design phase, as the size and placement of station facilities also affects energy consumption.
  - For example, within a rapid transit station escalators and elevators can consume one quarter of the energy used, so a station with a shallow vertical alignment will have shorter circulation runs and less electricity will be used as a result.
- New construction should be metered for electricity use and have intelligent control systems to permit measurement of electricity consumed and promote conservation efforts.
  - Working with consultants and contractors that have knowledge of sustainable design and construction practices can improve the long term results.
    To this end, contracts can be developed to promote improved energy consumption through the cost sharing of demonstrated improvements through innovation.
- Most importantly, energy consumption has to be measured and monitored. This will permit transit organizations to confirm designs, and make modifications to systems and patterns of use for the responsible use of energy.
- Use smaller scale solar panels for signage, emergency phones, canopy lighting, closed circuit systems, microwave transmitters, and other applications to power small load requiring equipment. The solar panels generate electricity during the day from the sun, and then also recharge a small battery, which can distribute electricity at night. Particularly, use solar panels for station or transit node signage, lighting, and other needs at elevated train line infrastructure.

measurement

For buildings and similar conditioned spaces, refer to LEED

system regarding building energy efficiency goals, monitoring, commissioning, and measuring.

- ***Outcome:*** Reduce energy usage.
- ***Output***
- ***Target:*** 10% energy efficiency improvement
- ***Indicator:*** Establish baseline at project inception; measure record energy required at project completion; monitor quarterly for life of facility.

case studies

Natural Ventilation and Heat Exchange Mechanical System, MTA NYCT: The recently completed Corona Maintenance Shop includes advanced design with apertures and ventilations louvers. Noteworthy is that during the very hot New York summer of 2006, the Corona Maintenance Shop did not require mechanical ventilation until the outside temperature reached upwards 85 degrees Fahrenheit (30 degrees Celsius). In the winter, the “make up” fresh air is heated to room temperature partially by the warm air leaving the building.

Natural Lighting/Daylighting, MTA NYCT: Corona Maintenance Shop was designed to include natural lighting (daylighting) to complement, and in some cases replace, electric lighting. It has been incorporated into the building through side-lighting and sky-lighting features.

Skylights with Photovoltaics, MTA NYCT: Roosevelt Avenue/74th Street Station’s adjacent bus terminal skylight contains translucent photovoltaic (PV) units to both transmit natural light and capture solar energy. Other roofs at this intermodal station also have photovoltaic panels.

Rapid Roll-Up Doors, MTA NYCT: Rapid roll-up doors in bus depots both enhance security and achieve energy saving benefit by minimizing heat loss.

Solar-Powered CCTV Cameras, MTA NYCT: To provide security at 20 of New York Yards, PV powered CCTV cameras are being used. The CCTV signals transmit wirelessly from the camera, and power to operate the cameras will generally be provided by individual solar panels which will: eliminating the need for trenching to accommodate cabling; eliminating the accompanying schedule impacts; and, providing the added advantage of using a renewable as well as grid-independent electrical energy source.

Fluorescent Lighting, MTA NYCT: Agency has been replacing incandescent fixtures with fluorescent lighting in stations. When T12 fluorescent lamps were installed, they produced lighting level increases at the stations of 750% while reducing power consumption by 28%. A further switch to T8 bulbs provided similar increased lighting levels with a further 26% reduction in power consumption. Annual lamp replacement was decreased, saving money. Altogether, fluorescent lighting in stations provided $5 million of savings annually while making stations brighter, safer, and more comfortable for the riding public and employees.

Compact fluorescent bulbs replaced conventional incandescent light in tunnels because the compact bulb design fit the same sockets. Compact bulbs offer the same benefits as longer fluorescent light tubes and have increased tunnel lighting 500 percent with just a modest power increase of 11 percent. What's more, since each compact fluorescent bulb consumes four-to-six times less energy than an incandescent bulb, the compact bulb yields 1,300 fewer pounds of carbon dioxide emissions over its lifetime of 7,500 to 10,000 hours.

Light Emitting Diode Signals, MTA NYCT: The agency has been replacing its incandescent train signaling lights with highly efficient light emitting diode (LED) Signals. Using LED signals means a 60 percent savings in energy compared with traditional incandescent light. LED lights improve brightness 150 percent, and they decrease greenhouse gas emissions substantially since the LED signals lower electrical demand and production. LEDs also have an extremely long life, which reduces landfill use and saves labor.

Changing subway signals from incandescent bulbs to LED reduces NYCT's annual electrical consumption about 6 times and thus about 5,000 metric tons of CO2 emissions are avoided annually, not to mention reduced maintenance labor and procurement/disposal cost due to longer life of the luminaire.

Lower Loss Transformers, MTA NYCT: By utilizing transformers for the Tunnel Lighting projects which have only an 80 degree temperature rise rather than the 115 degree rise commonly used in the industry. The specified transformers dissipate less heat and use less energy.

Sleep-mode Escalators, MTA NYCT: Agency has installed sleep-mode switches on escalators to save electricity at times of low ridership.

3.3 GUIDELINE 2

Partner with Local Power Utility

principles

- Leverage utility's expertise in energy production.
- Leverage transit agency's long term facility ownership.
- Select pilot projects that fit transit project's goals, funding, and budgets.
- Use pilot projects to 'mainstream' transit agency-wide initiatives.

recommendation

As transit infrastructure typically has a long life cycle, its buildings and sites can present opportunities for small scale electricity generation. The roofs of large maintenance facilities have been used by transit organizations for photovoltaic panel installations and some properties have used track right-of-ways for the same purpose.

Also, refer to 3.3, Guideline 1.

- Optimize the public investment in shared infrastructure by partnering with the local utility to establish shared goals for the region.
- Assess the best source of energy to be used in the transit system based on local infrastructure and availability. Total carbon footprint of the system must take the energy source into account, and different opportunities for "clean" energy are available depending on the regional location of the system.
- Pursue partnership projects with utility that demonstrate environmental stewardship, e.g. investment in alternative energy sources to serve the energy needs of new transit systems.
- Pursue partnership projects with utility that result in utility investment in alternative transit technologies that will reduce overall system energy consumption.
- Seek opportunities to consume and store energy during off-peak periods. This will both reduce regional energy consumption during peak periods but will also reduce cost to the transit agency

context

Transit systems are heavy users of electricity. While it may not be possible to be self sustaining with renewable energy sources, it is highly desirable to be able to offset some electricity consumption. Utility companies also gain the advantage of having highly visible projects to show where they are getting their Green Power.

measurement

- ***Outcome:*** Partnering agreement with local utility reducing utility usage.
- ***Output:*** Signed agreement by Transit and Utility Authorities.
- ***Target:*** Arrange to open grid to allow for TA o fed back to the grid. Partner with utility to use transit ROW to harvest energy (wind/solar, other). Utility to maintain and reap energy production.
- ***Indicator:*** Record KW produced from infrastructure/facility (roof) used to harvest renewable energy.

case studies

TriMet's Partnering with Local Utility: TriMet is partnering with Portland General Electric (PGE) to design and construct innovative renewable energy initiatives.

The Portland Mall Revitalization project will include both photovoltaic (PV) and vertical axis wind turbines (VAWT). Renewable energy tax credits will help fund these innovations by including a private third party investor.

The modes served at the Transit Center include:

- Photovoltaic panels are included on the exterior structure of the new substation and communication buildings.
- Panels will generate more than 50 kilowatts of power through renewable solar energy.
- 22 Vertical Axis Wind Turbines to be mounted on top of the light rail's catenary poles will provide an additional 275 watts of power.
- The renewable energy will be fed directly into the electrical utility's power grid.
- The panels and turbines will generate enough power to run LED site lighting, lighting fixtures which illumination of the exterior screen wrap, and the buildings' electrical

systems.

- The agency and Portland State University will monitor the energy output from the site's alternative power sources and report on its performance.

Disposal of Wood Ties, BART: When worn out wooden ties are replaced, BART sends them to a cogeneration plant where they are used to make electricity. BART partnered with the Wheelabrator Shasta Energy Company of Anderson California to shred and burn all scrap wooden ties. The unique plant is equipped with state-of-the-art air quality controls.

The project addresses the entire life cycle of rail ties. New ties require less energy to create and divert materials from landfills. Worn ties are responsibly disposed of and used to produce electricity, which comes back to power BART facilities.

Photovoltaic Panels (PV), MTA NYCT: In the mid-nineties, New York's NYCT started installing solar power units and, to date, these include: a 300kW system on top of Gun Hill Road Bus Depot - one of the largest PV facilities on East Coast; a small 65 kW PV system at Roosevelt Ave-74th Street Station; the Corona Maintenance Shop 100kW rooftop system completed in 2006; and, the 60,000 square foot photovoltaic (PV) canopy over Stillwell Terminal which draws international attention in addition to producing 250kW of clean power. The agency is installing PV directly on elevated platform canopy roofs undergoing rehabilitation. Different types of PVs and mountings are being analyzed to minimize capital and maintenance costs.

Fuel Cell Heat Recovery, MTA NYCT: 200 kW Fuel Cell unit, installed with support from the New York Power Authority on the roof of the MTA-NYCT Corona Maintenance Shop to supplement existing electrical service, also utilized waste heat, created by exothermic electrochemical reaction, to heat shop's domestic hot water supply. Fuel cells convert hydrogen and oxygen into heat and electricity. This converts power more efficiently, and with less pollution.

more information

AC Transit: Hydrogen Fuel Cell Buses, Solar Power Electrical system (for facilities)
www.cleanfleetreport.com/fleets/ac_transit.htm

CALSTART-WESTSTART

www.calstart.org/

California/Sweden Biomethane collaboration*
www.resources.ca.gov/press_documents/CaliforniaSwedenBioenergyMOURelease_06_29_0

*There are more than 8,000 vehicles operating on biomethane in Sweden today; the gas utility in Gothenburg set a goal of 100% renewable methane by 2050.

3.3 GUIDELINE 3

Optimize Efficiency of Rail System

recommendation

- Regenerative braking systems on the trains captures energy from braking vehicles and feeds it back into the power distribution system for use by adjacent trains. Alternatively, this regenerated power can be stored in wayside storage systems.
- For heavy and light rail vehicles, the efficient distribution of electricity to the traction power system is paramount to minimize electricity use. This includes the frequent and regular placement of substations along the alignment.
- Refer to 4.3, Guideline 4.

context

Infrastructure design can have a significant affect on the energy consumption of transit facilities. Since the vast majority of the electricity in an electrified rail system goes into the traction power system to move the vehicles, it is important to optimize the operational efficiency of the system.

measurement

- ***Outcome:*** improve rail efficiency
- ***Output***
- ***Target:*** improve rail efficiency by ?%
- ***Indicator:*** monitor record replacement of steel rail to say, aluminum rail results in improved electrical efficiency by?
- Report on associated LCC and LCA with detailed breakdown.

3.3 GUIDELINE 4

Minimizing Transmission Losses

recommendation

- Traction Power - transmission losses in 3rd rail
- Traction power distribution - need to look at substation spacing and distribution - network level
- Then AC to DC and down to actual distribution use running rail - lot of transmission loss.
- Recently some transit systems have been developing third rail systems with less electrical resistance than the heavy steel rail historically used. Aluminum third rail with a steel cap plate for wear resistance is being tested in New York City's MTA. Need good support in the design process to lay out more effect designs
- Design the optimum spacing and number of substations. This can make large difference in efficiency and energy use.

measurement

- ***Outcome:*** reduce transmission losses
- ***Output***
- ***Target:*** reduce transmission losses by ? %
- ***Indicator:*** monitor record replacement of steel rail to say, aluminum rail results in reduced transmission losses by?
- Report on associated LCC and LCA with detailed breakdown.

case studies

Aluminum Composite Third Rail, MTA NYCT: For the 3rd Rail, NYC Transit is utilizing aluminum composite rail to be used in place of an all-steel rail. A steel and aluminum composite rail is made of a steel base rail with aluminum cladding on its sides. Because aluminum is a better conductor of electricity than steel, there are less energy losses experienced in the system (50% less). It has been installed in Corona Yard, will be installed for South Ferry, and is being used for normal rail replacement by Operating Departments.

All Aluminum Third Rail, MTA NYCT: For the 3rd Rail, NYC Transit is experimenting with an energy saving all aluminum rail.

This rail is even more energy saving than aluminum composite rail. It is composed entirely of aluminum with a 6mm stainless steel cap on the head of the rail. This rail has a greater amount of aluminum in its cross section than aluminum composite rail so the reduction in energy losses in the rail is even greater (65% reduction vs. 50% reduction for aluminum composite rail). The durability of such rail is being evaluated. It cannot replace typical steel rail in the existing track designed for different rail weight (unlike the composite), but it can be designed for on the brand new systems. It also allows for greater spacing between substations. (mta.info/nyct/facts/ffenvironment.htm#green_build)

3.3 GUIDELINE 5

Consider Innovative Approaches to Energy Usage

recommendation

- Electric vehicle connections at stations. Charge cars during off-peak.

context

measurement

- ***Outcome:*** reduce overall energy usage
- ***Output:*** based on records, show annual reduction in energy usage of transit/system and/or
- ***Target:*** reduce energy usage by ? %
- ***Indicator:*** monitor/record energy usage reduction?
- Report on specific changes in operation or equipment with associated LCC and LCA with detailed breakdown.

ambient environment & health

Intent & Scope

This section provides guidelines for creating a positive and healthy ambient environment within transit facilities and along transit corridors in order to attract and maintain riders. Ambient environment is considered in three tiers:

- comfort,
- health, and
- safety.

guidelines

Four guidelines are provided for Ambient Environment & Health under Infrastructure & Facilities, and are discussed in more detail in the following subsections:

guideline 1: Provide Inviting Spaces/Art/Entertainment

guideline 2: Enhance Wayfinding

guideline 3: Provide Weather Protection

guideline 4: Maximize Comfort and Safety

3.4 GUIDELINE 1

Inviting Space/Art/Entertainment

recommendation

A positive ambient environment that is critical to attracting and maintaining riders and improving community viability and individual health and well-being.

- ***Create a welcoming atmosphere and sense of quality service:***
- Public spaces should be clean, free of litter, unpleasant odors, and graffiti.
- Acoustics should allow travelers to hear public address announcements on the platforms; control excess noise and vibration.
- Lighting levels and fixtures should be functional and aesthetic, to provide good visibility and additional security. Consider daylighting regularly occupied spaces.
- Public amenities can include shops, telephones, benches, and safe, clean toilet facilities.
- Use landscaping and hardscaping to make the space pleasant.
- Maintain thermal comfort. Provide wind breaks, where needed. Recommended zone ranges from X-Y degrees.
- ***Design of Transportation Infrastructure Elements:*** Overhead aerial structures, vents, tunnels, and other elements should be a collaborative effort between engineers and architects, to blend aesthetics with essential technical criteria. Examples of transforming utilitarian elements of transportation to viable community features include:
- Creating a linear park and bike path beneath or parallel to a transit aerial structure
- Designing a bridge that enhances civic pride
- ***Connect to the Outdoors:*** Design spaces and provide openings to visually connect the indoor environment and outdoor spaces.
- ***Public Art:*** Integrated art within and around of public transportation facilities to complement the design of

stations and transit infrastructure. Architects, engineers, and artists should collaborate at the earliest possible stages of a project to integrate art within architecture, landscape design, and structural engineering. Each project and facility should be evaluated by the design team for the potential to integrate art in various forms. Art can be simple, temporary or permanent. Public art can be integrated within transportation facility design in many ways; consider the following two:

- Leveraging the opportunities to create art from necessary and functional architectural and structural spaces and elements.
- Reflecting the history and cultural diversity of station and transit node locations, thus linking the transit system to communities.
- ***Architecture:*** While the architecture itself enhances stations through various functional elements such as grills, railings, bollards, elevators, signage, lighting, ceiling and wall treatments public art, engaging local artists, can be integrated and enhance these elements as well. Within transit facilities, architects can widen the opportunities for public art, by considering collaborating with artists addressing transit specific spaces and elements not found in other locations. Additionally, some transit spaces may provide good acoustics, for scheduled musical presentations.

context

The above recommendations create a positive ambient environment that is critical to attracting and maintaining riders. They:

- Enrich the experience of travelers,
- Make transit facilities welcoming spaces that reflect local cultures and activities,
- Reduce motivation for crime, vandalism, and other anti-social behavior.
- Reduce stress. Provide mental health benefits…MORE FROM HEALTH EXPERTS

measurement

- ***Outcome:*** Make the experience of using transit facilities and corridors so positive that people choose transit over less sustainable modes.
- ***Output:*** Discuss and document consideration of ambient environment in design of all stations/transit nodes/terminals/stops. Conduct rider surveys to collect information on performance and areas for improvement.
- ***Indicator:*** % of riders satisfied with atmosphere in facilities
- ***Target:***
- 70% of riders surveyed respond that they are happy with the atmosphere in each transit stations/transit nodes/stop/terminal
- 60% of riders say they would rather take transit than drive partially because they enjoy the experience of using transit stations/transit nodes/stops/terminals

case studies

Case Studies: (Photos to be added)

At freeway median stations, station public address systems should consider acoustical quality and traffic noise when locating speakers on the platforms.

Public art in transit facilities can be entertaining for pedestrians making station connections. In downtown Oslo, a tunnel walkway was converted to an underground art gallery with three-dimensional sculptural work.

An extension of the Stockholm Metro, articulated by colorful artwork, is known as the world's longest art gallery, and illustrates how utilitarian spaces can accommodate public art.

This sculptural element within a transit station celebrates civic pride, and promotes appreciation of art. LOCATION?

At Chicago's O'Hare United Airlines Terminal Tunnel, air travelers making connections experience a colorful, kinetic and musical light show.

3.4 GUIDELINE 2

Wayfinding

recommendation

Provide effective wayfinding at each station/ terminal/ stop/ transit hubs (referred to as station/ hub below). Include the following attributes:

- Identify stations/hubs with signage so that the public (pedestrians, bicyclists, private automobile users, and transit riders) recognize its location. Use operator logo and particular colors to identify various transit services or routes.
- Within station/transit node/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.
- Identify specific platforms and stops with operator logos and route designations (colors, numbers, and letters) and destination names.
- Within station/transit node/hub include wayfinding signage and maps directing customers out to nearby streets, attractions, and landmarks.
- 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 of and throughout station/transit node/hub and on the internet.
- Provide regional transit information by phone, internet, and via take-away brochures and maps.
- Communicate fares and schedules.
- Implement single card fares when practical.
- Make wayfinding simple and intuitive – easy to understand, regardless of the user's experience, knowledge, language skills, abilities or disabilities, or current concentration level.
- 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.

- Efficiently design transit facilities so that communication, ticketing, signage, etc, are centrally located to reduce maintenance required to support these various elements.
- Information should be presented in a consistent manner among transit systems to aid customers' understanding.

context

Good wayfinding aids travel planning and execution and may result in increased ridership, decreasing the environmental impact of automobiles.

Wayfinding is an essential element in transit connectivity. Connectivity is an indicator of a customer's ability to use more than one transit system for a single trip. Effective connectivity improves a transit trip that requires multiple operators to travel to work, school, a government service center, a shopping district, or other destinations. By making a multi-operator trip nearly as easy as a single operator trip, good connectivity can attract new transit riders — and retain existing riders and increase people's mobility. Good connectivity results in a convenient and 'seamless' transit system by reducing travel times, providing more reliable connections, making it easier to pay, and ensuring that transfers are easy and safe.

measurement

- ***Outcome:*** Make navigating a transit system a stress free activity requiring minimal effort that results in increased ridership.
- ***Output:***
- Meet with stakeholders and survey riders to determine how wayfinding system should be improved. Provide meeting notes and respond to stakeholder comments.
- Evaluate wayfinding at each station/terminal/stop through an in-house audit, third-party audit, or rider survey. Address areas where wayfinding is found to be lacking. Document and provide to stakeholders.
- ***Indicator:***
- Survey of riders on quality of wayfinding
- Record complaints about wayfinding
- ***Target:*** 85% of riders report satisfaction with wayfinding when surveyed

implementation

- Plan and execute upgrades where wayfinding is found to be lacking.

case studies

An example is the wayfinding graphics at platform of Barcelona Metro, which lead patrons to their planned destinations and also offer information regarding other attractions.

Case Study to be expanded upon: MTC Hub Wayfinding program. Includes Transit Information Display Cases and Kiosk units of consistent design which will hold information posters and maps which will be kept up to date with current information from transit agencies serving various hubs. For example: Route, fare and service hours information will be kept up to date.

more information

Transportation Research Board, Transit Cooperative Research Program (TCRP): *Report 12, Guidelines for Transit Facility Signing and Graphics.*
www.tcrponline.org/bin/publications.pl

San Francisco Bay Area's Metropolitan Transportation Commission (MTC), MTCH Regional Transit Connectivity, Regional Transit Hub Signage Program, Technical Standards and Guidelines

3.4 GUIDELINE 3

Weather Protection

recommendation

Design stations/transit nodes/stops/terminals to protect riders from weather conditions.

- Shield riders from wind.
- Provide covering from rain and snow
- Provide shade
- Provide relief from extreme heat and cold

context

Individuals will be more like to choose to ride transit if conditions at stations/transit nodes/stops/terminals are comfortable.

measurement

- ***Outcome:*** Increase comfort of riders by providing the maximum feasible level of protection from weather conditions. Increase ridership.
- ***Output:*** Evaluate weather protection at stations/stops/terminals. Develop and implement plan for improvements.
- ***Target:*** Consider weather protection in all station/terminal/stop designs. Add and/or maintain protection elements at X percentage of facilities. Increase percentage at set intervals.
- ***Indicator:***
- Percentage of stations/stops/terminals that have weather protection features.
- Percentage of riders who are satisfied with weather protection features.

case studies

Louisiana/Pearl Station: The Southeast Corridor of ***Denver's RTD's Light Rail*** system was built between 2001 and 2006 as part of the Transportation Expansion Project (T-REX for short). As much as possible, each station had neighborhood input as part of the design process. At Louisiana/Pearl, a major concern was to maintain the intimate neighborhood scale before and after the project, and no onsite parking was desired. The station was designed as a neighborhood station with easy pedestrian access and designated passenger drop-off and pick-up areas. Louisiana/Pearl also offers better than average weather protection. Transit riders from the South Pearl and Washington

Park neighborhoods typically walk to the station and leave their automobiles at home.

Studies show that a station affording better than average weather protection encourages higher ridership and usage, even when there is no provided on-site parking.

The weather protection and visual benefits include:

- Creation of a street level plaza with visually attractive amenities that draw passengers to the station entrance. Two glass elevators provide barrier-free access to the train platform.
- Placing the station below grade, with the street-level plaza forming an overhanging deck to protect passengers from wind, rain and snow.
- RTD's Art-n-Transit program included working with local artists to create a site-specific canopy design depicting natural leaves. This canopy covers the stairs that descend from the street level plaza to the platform level below.

The platform level is permanently shaded from the intense Colorado sun and feels several degrees cooler in summer. During inclement weather, the lower platform is shielded from wind, rain and snow, thereby providing a more comfortable wait for passengers. This eliminates the need for platform and highblock canopy structures as well as reduced use of magnesium chloride salts on the actual platform to melt snow and ice.

Stillwell Terminal Canopy, MTA NYCT: Stillwell terminal is a largest aboveground station in the NYCT system, serving 4 lines and its 80,000sf new canopy is spanning over 8 tracks. The weather protection of a continuous canopy roof was selected instead of several smaller canopies because the continuous canopy provides is significantly better protection especially at this windy location near the ocean. The Stillwell canopy also has 250kW rated BIPV system of semitranslucent thin-film solar cells embedded in glass and surrounded by clear strips to let the light in. The system produces over 200MWh annually of clean energy while letting just enough light onto the platform and blocking too much sun in the process.

3.4 GUIDELINE 4

Comfort and Safety

recommendation

Make the transit environment as safe as possible and take extra steps to make patrons feel safe. Important elements include:

- ***Crime Prevention:*** Common crimes occurring in transit systems include vandalism, theft, especially of cash revenues from stations or transit nodes, and other crimes of opportunity. Crime Prevention through Environmental Design (CPTED, pronounced sep-ted) is a low-tech strategy that that encourages people on the street and in neighborhoods to look out for each other. These principles are aimed at reducing fear and incidence of crime and maintaining quality of life:
- *Natural Surveillance:* Create an environment that allows people to observe the spaces around them. Maximize visibility and views of streets and neighborhoods.
- *Natural Access Control:* Limit access and increase natural surveillance to either keep criminal intruders out or make them more easily marked as intruders. Use strategic placement of entrances, exits, fencing, lighting, and landscaping to control or limit access.
- *Natural Territorial Reinforcement:* Design environment to clearly delineate private space, to create a sense of ownership among neighborhood residents. Design and siting of buildings, fencing, pavement, signs, lighting, and landscape elements can express ownership and define public, semi-public, and private spaces.
- Use visible crime prevention elements, such as posting information on security cameras and providing phones.
- ***Safe Access to Transit:*** Partner with community to achieve safe walking routes to transit. Achieve high quality streetscapes with wide walk-ways that encourage community use.
- ***Take a Multi-Disciplinary Approach to Security Planning:*** Architects, engineers, landscape designers, security personnel, law enforcement, community groups, and public officials should collaborate to develop security

plans for transit systems. Integrate design, technology, and operations into security plans early in the planning and budgeting stages.

- ***Balance Security and Openness:*** Transparent security, invisible to the public eye, can further enhance the sense of openness within transit public spaces. However, there are locations and times when public officials desire a show of security and force, based on potential threats, activities, tips, and public events. Transit systems should plan for the flexibility to increase or lower security levels and activities.
- ***Lighting:*** During an emergency, the public should be able to see where the exits are, and exit from stations and buildings quickly and directly to the outside. Good lighting also serves as a deterrent to crime.
- ***Means of Egress Out of Stations and Buildings:*** Must be clearly marked. The numbers, locations and widths of the exits should be planned to allow peak loads of people to exit in a short time, especially in the event of a fire or explosion. Access for first responders entering the stations or buildings at the same time that people are exiting, should be considered when planning locations and widths of stairs and doors.
- ***Security Provisions as Added Amenities:*** Setbacks from the street, bollards, planters, barriers, benches, and other street furniture engineered to resist vehicles can mitigate the impact of vehicular threats and help protect buildings from potential damage in a blast.

context

Providing the safest possible transit services directly improves human health and well-being. It is a direct means to help people better meet today's needs without harming future generations.

Promoting a perception of safety within transit stations/transit nodes/terminals/stops and on vehicles/vessels is a key element of a positive ambient environment. This will aid in sustaining current riders and attracting new ones, decreasing automobile usage and improving sustainability.

measurement

- ***Outcome:*** Provide the safest possible mobility alternative in a way that makes patrons feel safe.
- ***Output:*** Create a comprehensive safety plan addressing

the elements recommended above. Hold meetings with stakeholders to gain knowledge of community-specific safety issues. Share meeting minutes and comment responses with stakeholders.

- ***Target:*** Set thresholds and monitor performance for actual and perceived safety. Thresholds should be tied to the budget or have other serious consequences. Example Targets:
- Less than X thefts per month reported on transit system
- Less than Y assaults per month reported on transit system
- At least 80% of riders feel safe at each transit station/transit node/stop/terminal at night
- ***Indicator:***
- Maintain crime and accident statistics. Record crime and accidents at real number over time period AND as percentage increases or decreases.
- Use survey information to determine perceived safety. Record survey findings AND percentage increases and decreases.

emissions & pollution reduction

Intent & Scope

This section provides guidelines for reducing the potential contribution of transit systems infrastructure and facilities to air and water pollution. 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.

Reference Standards

GHG Monitoring: The World Resources Institute Greenhouse Gas Protocol (GHG Protocol) is the most widely used international standard for the quantification of greenhouse gas (GHG) emissions. The Protocol has worked with businesses, governments, and environmental groups around the world to develop a transparent, consistent, and credible framework for measuring and managing emissions. The Protocol Initiative has led to the creation of a suite of GHG calculation tools. A complete listing of all tools provided by the GHG Protocol can be found at: www.ghgprotocol.org/calculation-tools/all-tools

Waste Reduction: ASTM International's waste management standards provide the guides, practices, and test methods pertinent to the process of handling residential, commercial, and industrial wastes. Examples of transit relevant waste management standards include: "Standard Practice for Use of Scrap Tires in Civil Engineering Applications" and "Standard Practice for Processing Mixtures of Lime, Fly Ash, and Heavy Metal Wastes in Structural Fills and Other Construction Applications." A list of all waste management standards provided by ASTM can be found at: www.astm.org/Standards/waste-management-standards.html

guidelines

Five guidelines are provided for Emissions & Pollution Reduction under Infrastructure & Facilities, and are discussed in more detail in the following subsections:

guideline 1: Mitigate Hazardous Materials and Preserve Air Quality

guideline 2: Design for Water Efficiency and Re-use

guideline 3: Establish Green House Gas Monitoring on Facilities

guideline 4: Implement Waste Management and Recycling

guideline 5: Control Erosion

3.5 GUIDELINE 1

Hazardous Materials and Preservation of Air Quality

recommendation

- Eliminate and reduce hazardous materials in transit stations, transit nodes, terminals, stops, and supporting facilities
- Keep records of existing hazardous materials along with precautions and remediation.
- Design facilities to minimize mold and mildew growth
- Clean tunnels for air quality (AQ)
- Take steps during construction to protect indoor air quality such as: Develop and implement an Indoor Air Quality (IAQ) Management Plan for the construction and pre-occupancy phases of facilities to prevent indoor air quality problems resulting from construction. Follow ASHRAE 62,Ventilation for Acceptable Indoor Air Quality. For mechanically ventilated spaces, follow ASHRAE 129.
- Prohibit smoking near building entries and operable windows.

context

Large quantities of major building and finishing materials are incorporated into transit stations, transit nodes, terminals, stops, and supporting facilities. Substances used to created material components and assemblies are not always evident. Hazardous substances are sometimes found in common materials.

This issue has unique importance for transit because a large number of people are frequently in small places. There are large concentrations of human activity per square foot per day in transit stations, transit nodes, and vehicles.

As a large purchaser, transit agencies have the opportunity to be a leader in best practices for ensuring hazardous materials are kept out of public and work places.

High standards for material specifications aid in ensuring the safety of selected products. Proprietary information may prevent fully knowledge of potential dangers. Creating a list of substances agency has zero and limited tolerance for and

working with contractors and manufacture may help. In-house systematic testing of major materials in another option.

Goals:

- Increase awareness of potentially hazardous substances that appear in common materials throughout the transit agency. Increase awareness of potentially hazardous materials within your agency's transit facilities
- Provide better control of hazardous substances and reduce, and eliminate hazardous substances from transit facilities.

- Take positive steps to preserve healthy air quality.

measurement

- ***Outcome:*** Improve AQ
- ***Output:*** Reduce particulates of ? in air
- ***Indicator:*** Record present particulates ? in air in given facility
- ***Target:*** Improve AQ by ?% reduction of particulates in air.
- Does agency have plan for avoiding or limiting hazardous substances from stations, transit nodes, terminals, stops, and supporting facilities? (Yes/No)
- Are large material procurements for use in stations, transit nodes, terminals, stops, and supporting facilities tested for hazardous substances? (Yes/No)
- Does agency work with manufactures to avoid and limit hazardous substances from materials used in stations, transit nodes, terminals, stops, and supporting facilities? (Yes/No)
- Incorporate requirement for minimizing toxic materials in the construction contracts and procurement contracts.

more information

- TTC's methods for addressing this issue – To be completed.
- Volatile Organic Compounds, (VOC) are pollutants that certain substances emit when they mix with the air we breathe. When NYC Transit installed a bus paint booth at the Grand Avenue Bus Maintenance facility in Queens, the agency used a green design with a carbon bed to absorb VOC released in air exhaust. A new regenerative thermal oxidizer also controls air pollutant

emissions. The new bus painting system in the Grand Avenue facility reduces environmental pollutants as much as 95 percent in comparison with conventional paint spray booths. The agency is retrofitting paint fluid applications at nine bus depots to reduce the volume of wasted paint in the bus painting process. Reducing paint volume not only saves paint but also means that it is necessary to remove fewer Volatile Organic Compounds (VOC) pollutants from air exhausts.

California's Proposition 65 Chemicals
www.oehha.org/prop65/prop65_list/Newlist.html (scroll down for complete list)

Toxic Air Contaminants:

Federal: 188 Hazardous Air Pollutants (HAPs) as defined by Clean Air Act
www.scorecard.org/chemical-groups/onelist.tcl?short_list_name=hap

CA: 184 Toxic Air Contaminants (TACs), as defined by CA Office of Health Hazard Assessment for the Children's Environmental Health Protection Act
www.oehha.org/air/toxic_contaminants/pdf_zip/Appendix%20A.pdf

3.5 GUIDELINE 2

Water

recommendation

- Utilize water efficient plumbing fixtures.
- Minimize vehicle washer water usage.
- Treat wastewater from car washing system for recycling within the washer.
- Neutralize effluents from car washing system before they are directed to city sewers.
- Design and operate water efficient irrigation systems. Make plant selections in accordance with water conservation principles.
- Promote infiltration of water back into groundwater, filter contaminants, help prevent water pollution, and slow down storm water runoff.
- Design the project site to maintain natural stormwater flows by promoting infiltration.
- Use storm water management techniques are pervious pavements, bioretention basins (rain gardens), vegetated roof treatment, and landscaped areas.
- Collect storm water and use for non-potable uses such as landscape irrigation, toilet and urinal flushing, and custodial uses.
- Provide oil/water separator system, bioswale, or similar mechanism to intercept runoff from parking facilities and filter contaminants.

measurement

- ***Outcome:*** Reduce water usage; reduce water runoff (consider these as separate items/goals)
- ***Output:*** Reduce water usage by ‘x’ gallons either overall for organization or per facility; reduce water runoff by ‘x’ gallons due to reclamation either by organization or per facility.
- ***Indicator:*** Monitor/record gallons of water no longer used by comparing utility invoices; monitor/record gallons of water reclaimed and reused (bus/car wash, etc.)
- ***Target:*** Reduce each water usage and increase water

reclamation by ?%.

case studies

Rainwater Collection and "Grey Water" Re-Use: NYC Transit has implemented a stormwater management program which is designed to minimize the hydraulic impact on the sewer system and minimize the use of potable water by recycling and using "grey water". Such "rainwater harvesting" can also contribute to flood control. At the Corona Maintenance Shop, a rooftop rainwater collection system was designed and constructed by CPM which drains rainwater into a 40,000-gallon underground storage tank that supplies water to a subway car washer. About half of the wash water (whether rain or municipal) is then collected for further re-use. This "grey water" is then used in the wash cycles but the final car rinse is done with clean water. A similar 200,000 gal system is installed at the Grand Ave Depot.

3.5 GUIDELINE 3

Green House Gas Monitoring on Facilities

recommendation

- Install permanent carbon dioxide monitoring systems that provide feedback on space ventilation performance in a form that affords operational adjustments.

measurement

- ***Outcome:*** Improve CO_2/air quality at all facilities.
- ***Output:*** Air monitors to be placed randomly and moved throughout the system recording CO_2.
- ***Indicator:*** Trigger levels should be issued indicating unacceptable readings.
- ***Target:*** Perfect CO_2 readings at all facilities.

3.5 GUIDELINE 4

Waste Management and Recycling

recommendation

- Set target for construction and demolition debris
- Recycling can be a source of revenue for certain materials. Identify these materials and create a system for regular sale.
- Include containers for recyclables at stations, station sites, transit nodes, and other facilities. Include paper products, bottles and cans, and compostable items, and other categories in accordance with local recycling capability.
- Consider requiring concessionaires to eliminate non-compostable and non-recyclable items. I.e. eliminating plastic bags.

measurement

- ***Outcome:*** Reduce construction/demolition debris.
- ***Output:*** By calling for selective demolition, and reuse and recycling of material reduce debris sent to landfills.
- ***Indicator:*** Waste manifests should show reduced construction waste demo/debris.
- ***Target:*** ?% reduction annually.

case studies

Innovative Waste Management (Red Birds' Sea Burial), MTA NYCT: (Inclusion of this topic to be discussed) Beginning in August 2001, over 1,200 retired "Red Bird" subway cars were disposed of by sinking them in offshore US waters to form reefs in Virginia, Georgia, South Carolina, Delaware and New Jersey. With this first and only undertaking thus far, NYCT saved roughly $15 million in disposal costs while helping improve the environment. In specific terms, retired Red Bird subway cars are stripped of components that float (oils, solids, etc.) or degrade, steam cleaned, loaded on barges and placed at sea. Sea burial of the cars aids in the formation of artificial reefs which have been shown by the NJDEP Division of Fish and Wildlife to boost the fish population significantly. These reefs have also become a boon to fisherman, sport anglers and divers. Consideration is being given to reefing an additional 2,600 cars over the next ten

years, starting in 2007.

Recycling of Construction and Demolition Debris, MTA NYCT: (*want a case study that talks about reuse/recycling more specific to transit – tunnel large amounts of dirt- reuse transit-specific materials)*

Recycling construction waste can result in the reduced demand for municipal landfill space. By establishing specific requirements in its construction specifications, agency has diverted thousands of tons of traditionally landfill-bound construction waste to beneficial reuse which also reduces the demand for virgin resources. In 2006, agency recycled approximately 30% of the Construction and Demolition waste from its projects. At the Stillwell Avenue Station and Roosevelt Avenue Station rehabilitation projects, between 80% and 85% of the construction debris was recycled. Concrete, metal, glass and paper were all recycled and, as an added benefit, transportation fuel consumption and exhaust emissions were decreased.

3.5 GUIDELINE 5

Erosion

recommendation

- Meet or exceed local requirements for reducing erosion during construction and in permanent facilities.
- Control measures include a sediment and erosion control plan (and its implementation) that conforms to United States Environmental Protection Agency (EPA) Document No. EPA 832/R-92-005 (September 1992), Storm Water Management for Construction Activities, Section 3 or local erosion and sedimentation control standards and codes, whichever is more stringent.

context

Erosion control measures achieve the following objectives:

- Prevent loss of soil during construction by storm water runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse.
- Prevent sedimentation of storm sewer or receiving streams.
- Prevent polluting the air with dust and particulate matter.

rolling stock & fleet

introduction

This section provides guidelines for improving the sustainability of elements unique to transit rolling stock and fleet. Recommendations are relevant to planning, procurement, design, construction and operation of rolling stock and fleet. For the purposes of these guidelines, rolling stock and fleet include:

- Rubber tired buses including various types of propulsion systems such as diesel, diesel hybrid, hydrogen fuel cell, compressed natural gas (CNG), and electric powered buses, including both on-board and off-board electrical power sources.
- Waterborne ferries.
- Rail vehicles including heavy and light rail as well as streetcars and self propelled railcars.
- Non-revenue vehicles used by transit staff and contractors to sustain the transit service.

These guidelines are intended to optimize energy use and concurrently reduce emissions. They also promote a positive rider experience and therefore encourage higher ridership and utilization of transit alternatives. Recommendations seek to balance the need to provide ecological protection and maintain stable economic conditions. Benefits include savings and revenue from improved environmental performance; enhanced environmental compliance; pollution prevention and resource conservation; new 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 energy used per passenger miles traveled and passenger capacity per system mile available.

References:

- Find best practices for recycling industrial materials with U.S. EPA's "Industrial Materials Recycling: Tools & Resources" (March 2008), available at www.epa.gov/epaoswer/non-hw/imr/pdfs/tools3-08.pdf
- OSHA www.osha.gov
- ISO 14001 www.iso.org
- APTA Procurement Standards
- APTA Sustainability Standards
- ADA Regulations
- Others to be added

The following guidelines are provided for this section, Rolling Stock & Fleet:

4.1 System Planning and Land Use

Guideline 1: Consider Vehicle Choice in System Planning

4.2 Materials

Guideline 1: Incorporate environmentally preferable materials into vehicle design

Guideline 2: Bus-specific Preferred Materials

4.3 Energy

Guideline 1: Complete Vehicle Design and Related Systems

Guideline 2: Rolling Stock and Fleet Operation

Guideline 3: Bus Rolling Stock Design

Guideline 4: Rail Rolling Stock Design

4.4 Ambient Environment & Health

Guideline 1: Inviting Space

Guideline 2: Bus Specific Experience

Guideline 3: Rail Specific Experience

4.5 Emissions & Pollution Reduction

Guideline 1: Measure and Reduce GHG Emissions from vehicle operation

Guideline 2: Reduce diesel use in bus operations

system planning, land use & site design

Intent & Scope

This section provides guidelines aimed at optimizing transit systems planning, land use and site configuration to reduce or eliminate impacts on the environment and minimize carbon footprint.

Reference Standards

Guidance on New Starts Policies and Procedures
www.fta.dot.gov/documents/Final_Guidance_NewStartsSmallStarts_Policies_Procedures.pdf

guidelines

One guideline is provided for System Planning and Land Use under Rolling Stock & Fleet, and is discussed in more detail in the following subsection:

guideline 1: Consider Vehicle Choice in System Planning

4.1 GUIDELINE 1

Consider Vehicle Choice in System Planning

principles

- Full life cycle consideration
- Reduce environmental impacts

recommendation

- Consider vehicle selection in system planning to impact energy use, power consumption, use of alternative fuels to reduce consumption and emissions

context

An analytical approach to vehicle system selection will result in the selection of a system that is more sustainable over the life cycle of the system

measurement

- ***Outcome:*** Reduced carbon footprint
- ***Indicator:*** record energy used and emissions emitted with existing fleet/system and compare to the new vehicles/system.
- ***Target:*** improve vehicle and system selection to achieve goal of meeting environmental requirements.

case study

SFMTA Choose by Alternative (CBA) workshop evaluated (9) vehicle types and (20) criteria to determine the best choice of vehicle for the Van Ness BRT corridor. The criteria included vehicle design items such as diesel, hybrid or electric trolley coaches, multiple doors, double deck buses as well as operational criteria like dwell time, shop and storage space required, and fare collection style. This workshop involved 27 stakeholders from a variety of agencies and departments. Each vehicle type provided pros and cons relative to capital and operational costs as well as environmental and operational impacts. While Van Ness Avenue currently operates electric trolleys use of this technology for the planned center running BRT would require additional overhead catenary. A sixty foot diesel hybrid was scored by the committee to be the most effective technology to use with minimal environmental impacts. (www.sfcta.org/content/view/306/152/)

materials

Intent & Scope

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

Reference Standards

Find best practices for recycling industrial materials with U.S. EPA's "Industrial Materials Recycling: Tools & Resources" (March 2008), available at www.epa.gov/epaoswer/non-hw/imr/pdfs/tools3-08.pdf

guidelines

Two guidelines are provided for Materials under Rolling Stock & Fleet and are discussed in more detail in the following subsections:

guideline 1: Incorporate environmentally preferable materials into vehicle design

guideline 2: Bus-specific Preferred Materials

4.2 GUIDELINE 1

Incorporate Environmentally Preferable Materials into Vehicle Design

principles

- Innovative approach
- Use of sustainable materials
- Reduced energy consumption
- Reduced environmental impact
- Measurement

recommendation

- Supercapacitor/ultracapacitor in conjunction with batteries to reduce the load on the batteries, extend their life and reduce waste
- Improved electronics and battery materials
- Light weight materials including aluminum and composite materials
- Improved glazing materials and proper choice of exterior colors to reduce heat losses and to reduce undesirable heat gain
- Durable and easy to maintain/clean - graffiti resistant
- Improved insulation and sound deadening materials reduces thermal losses and lowers noise levels.
- Utilize environmentally acceptable refrigerant (in accordance with Montreal Protocol) in vehicle heating, ventilation, and air conditioning (HVAC) units.
- Applying low VOC and water based adhesives and coatings reduces harmful emissions
- Consider flooring and other finishes selected with environmental as well as durability in mind (refer to LEED System for typical selection criteria).
- Design or replace vehicle lighting fixtures and lamps with more energy efficient types, i.e. fluorescent or light emitting diode (LED).

context

Use of preferable materials reduces green house gases, improves air quality, reduces energy used and reduces toxic chemical waste production

measurement

- ***Outcome: R*** educed carbon footprint
- ***Output:*** choose materials with great Life Cycle Analysis (LCA) indicators.
- ***Indicator:*** record whether reused material, or recycled content of material; or produced locally, etc. Record energy consumption, emission reduction and toxic waste production
- ***Target:*** improve material choices annually to ultimate achieve goal of all materials meeting environmental requirements.

case study

New Millennium Trains and better materials: MTA NYCT's New Millennium Trains (NMT) have numerous features that conserve energy. The NMT cars use lighter construction material, but of equal or higher strength. The lighter floors make a lot of difference. Older trains will also be retrofitted with lighter floors.

more information

Low VOC Paint
www.eartheasy.com/live_nontoxic_paints.htm

corporateportal.ppg.com/NA/Refinish/PPGRefinish/2-0-Products/050_Envirobase/EN

Ultracapacitors
www.ultracapacitors.org/

NABI Compo Bus
www.nabusind.com/NABI/compo-bus.htm

4.2 GUIDELINE 2

Bus-Specific Preferred Materials

principles

- Innovative approach
- Reduced energy consumption
- Reduced environmental impact
- Measurement

recommendation

- Multiplexing in bus electrical system to reduce wiring, which will reduce copper usage and bus weight
- LED strip lighting in buses will eliminate fluorescent tubing and ballasts

context

Use of preferable materials reduces green house gases, reduces energy used and reduces toxic chemical waste production

measurement

- ***Outcome: R*** educed carbon footprint
- ***Output:*** choose materials to reduce energy and materials usage
- ***Indicator:*** Record energy consumption, emission reduction and toxic waste production
- ***Target:*** Improve material choices annually to ultimate achieve goal of all materials meeting environmental requirements and reduced energy consumption.

case study

In 2008 Dialight Corporation joined forces with two of North America's leading manufacturers in the transit bus and motor coach market, Hadley and New Flyer, to provide the industry's first complete ***LED-based interior lighting system***.

more information

Bus Multiplex Systems
www.iocontrols.com/product/3G.php

Bus LED strip light alternative to fluorescent tubing
www.dialight.com/News.aspx?id=55

energy

Intent & Scope

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

guidelines

Four guidelines are provided for Energy under Rolling Stock & Fleet and are discussed in more detail in the following subsections:

guideline 1: Complete Vehicle Design and Related Systems

guideline 2: Rolling Stock and Fleet Operation

guideline 3: Bus Rolling Stock Design

guideline 4: Rail Rolling Stock Design

4.3 GUIDELINE 1

Complete Vehicle Design and Related Systems

principles

- Innovative approach
- Reduced energy consumption
- Reduced environmental impact

recommendation

- Conserve energy through innovative, more efficient lighter weight vehicles and component design. Use aluminum and lightweight composite materials to reduce vehicle weight.
- Alternative propulsion systems include adding sails, photovoltaic electric, battery electric, flywheel generator, ICE generator electric, hybrid sail-PV-battery-generator, fuel cell and regenerative electric drives or a gas turbine.
- Hydrogen Fuel Cell: A fuel cell is an electrochemical energy device that generates electricity for powering motors, lights, buildings, etc. Fuel cells convert hydrogen and oxygen into electricity and heat. This creates power more efficiently, and with less pollution.
- These designs can incorporate innovations such as light weight wheels, fewer motors, light weight modular HVAC systems, light weight, aluminum or composite structural materials, and improved propulsion systems. These elements reduce the energy required to propel the vehicle.
- Innovative designs can also include the use of energy saving lamps and lighting such as LED lights, or openable windows in some locations to allow the elimination of air conditioning systems, as well as energy storage units, better battery technology and right sizing the vehicles.

context

Short-term Goal: Increase awareness of total environmental impacts and ability to make more informed choices.

Long-term Goal: Maximize use of designs and practices that support high quality transit service with the lowest possible energy impacts

measurement

- ***Outcome: R*** educed energy consumption
- ***Output:*** choose technology that reduces energy use
- ***Indicator:*** improved fuel mileage, reduced power consumption, use of renewable fuels
- ***Target:*** improved vehicle designs to ultimate achieve goal of reduced energy consumption

more information

May 2003, the International Association of Public Transport (UITP) Charter for Sustainable Development

Shapiro, R. J., K. A. Hassett, et al. (2002). Conserving Energy and Preserving the Environment: The Role of Public Transportation, Report for American Public Transportation Association.

Bailey, L. (2007). Public Transportation and Petroleum Savings in the U.S.: Reducing Dependence on Oil, Fairfax, VA, Prepared for American Public Transportation Association by ICF International.

4.3 GUIDELINE 2

Rolling Stock and Fleet Operation

principles

- Innovative approach
- Reduced energy consumption
- Reduced environmental impact
- Renewable energy source
- Optimize energy efficiency

recommendation

- Maximize automated train service to achieve more efficient starts and stops.
- Select automated control systems which save on traction power required to propel the train thus conserving energy (i.e., maximizing acceleration and braking rates, and/or using a Brake Profile Monitor system to minimize power/brake transitions).
- The use of synthetic lubricants will decrease the frequency of oil changes required and extend drive train life, which will reduce waste materials.
- Communications-Based Train Control
- Computer modeled transit operations and passenger loading can be used to plan fewer stops.
- Conducting proper PMs on rolling stock will increase fuel efficiency and reduce emissions.
- Provide bus rapid transit, where feasible, saving energy and reducing emissions while improve service.

context

Improved operations can reduce energy consumption and reduce emissions

measurement

- ***Outcome: R*** educed energy consumption
- ***Output:*** Implement technologies that reduce energy consumption
- ***Indicator:*** reduced energy consumption
- ***Target:*** improved fleet operations to reduce energy consumption

case study

Subway Car Field Shunting Elimination Program, MTA NYCT: In 1996, NYC Transit began the Subway Car Field

Shunting Elimination Program, one of its most successful energy conservation projects. The program is oriented at modifying the field strength of the DC series motors that move the subway cars through elimination of the shunting of a portion of the field windings, which inhibit acceleration of the DC cars in the subway fleet. The implementation of the elimination of shunting results in a 12% reduction of energy use per car mile and NYC Transit currently produces a savings of 240 million-kilowatt hours of electricity annually. The process also reduces the peak electricity demand during all weather and operational conditions, with no measurable impact to maintenance or schedule.

Communications Based Train Control (CBTC), MTA NYCT: A pilot CBTC system was recently completed on the MTA NYCT's Canarsie Line. The CBTC system integrates command and control of virtual signals and communicates with the trains on the line through a network of wayside radio units improving the "headway" of trains. This technology can be the future of the agency's train control because the improved headway produces increased line capacity and passenger travel time savings. Thus, increased ridership can be supported and increased ridership translates into more cars taken off the road, which results in less emission of CO2 and other air pollutants into the atmosphere. Additional power savings and corresponding reduced emissions of air pollutants may also result from smooth and controlled acceleration and deceleration/braking produced by the CBTC system. The plans for conversion of another line to CBTC are underway.

more information

May 2003, the International Association of Public Transport (UITP) Charter for Sustainable Development

NYCTA Field Shunt Program
www.mta.info/nyct/facts/ffenvironment.htm

4.3 GUIDELINE 3

Bus Rolling Stock Design

principles

- Innovative approach
- Conserve energy
- Reduce emissions
- Renewable energy source
- Optimize energy efficiency

recommendation

- Conserve energy by utilizing hybrid bus designs. These designs incorporate steady state operations and regenerative braking which reduces energy consumption.
- Utilize Biodiesel fuel
- Be aware of developments in battery and hydrogen fuel cell technology.
- Conserve energy by optimizing transmission shifting points to improve fuel economy and by utilizing electronic engine and transmission controls.
- Reduce energy usage by reducing bus idle times
- Electronic technology allowed the use of modular and roof mounted air conditioning and engine cooling systems to be developed, resulting in less auxiliary loads on the vehicle power plant thus reducing energy consumption.

context

Improved operations can reduce energy consumption and reduce emissions. Use of sustainable fuel reduces demand on hydrocarbon based fuels.

measurement

- ***Outcome: R*** educed energy consumption
- ***Output:*** Implement technologies that reduce energy consumption
- ***Indicator:*** reduced energy consumption
- ***Target:*** improved fleet operations to reduce energy consumption

case studies

Department of Energy (DOE) and National Renewal Energy Laboratory (NREL) have been evaluating alternative fuel transit buses with FTA since the early 1990s. In 1996, DOE and

NREL completed an evaluation of transit buses at eight transit agencies that included six different alternative fuels. Since the 1996 study of alternative fuels in transit, NREL has completed seven additional evaluations of natural gas and hybrid propulsion transit buses. NREL's first evaluation of hydrogen-fueled transit buses was in 2000. The current hydrogen transit bus evaluations include four active projects and two that were completed in the last few years. The FTA is at the forefront of the research, development, and demonstration of fuel cell transit buses. Fuel cell technology is especially interesting to FTA because it holds the promise of greatly reduced emissions, quiet operation, and reduced fuel consumption for transit fleets. The FTA's newest development program is the National Fuel Cell Bus Program (NFCBP) designates $49 million in funding for 2006 through 2009 to help develop commercially viable fuel cell buses and technologies. The FTA competitively selected three nonprofit organizations—the Center for Transportation and the Environment (CTE), the Northeast Advanced Vehicle Consortium (NAVC), and WestStart-CALSTART—to administer projects under the program.

CALSTART and its project teams are part of the comprehensive NFCBP to help knock down the barriers to commercial use of clean fuel cell technology in transit over the next several years. It drives forward a focused, multi-year strategy to speed key improvements in fuel cell reliability, system design and component design. The goal is more affordable, higher performance fuel cell systems becoming available for transit bus and other uses. This program includes: the next generation fuel cell bus, an advanced lithium-ion energy storage system, an advanced electric motive drive system and targets doubling the fuel efficiency of a diesel bus in an affordable package.

The many environmental benefits of fuel cell buses include:

- reduced dependence on petroleum
- diversifying domestic energy sources
- decreasing pollution
- reduced greenhouse gas emissions

Diesel Hybrid Electric Buses , MTA NYCT: Over 600 Diesel Hybrid Electric Buses are in currently use in New York. These buses consume less diesel fuel and thus produce less PM,

SOx, NOx and CO2 air pollutants.

Ultra Low Sulfur Diesel (ULSD) Fuel, MTA NYCT: ULSD and diesel particulate filters (DPF) have been used in over 4,500 New York buses since 2000. Over 40 million gallons of ULSD are used annually and result in ambient air particulate reductions that otherwise could affect ambient air quality and respiration.

Compressed Natural Gas (CNG) Fuel, MTA NYCT: CNG Buses have been in use since 1996. Today, a fleet of 479 CNG Buses in New York utilize over 7 million gallons of CNG annually. CNG buses emit less PM and SOx than conventional diesel buses and support continued improvement of the ambient air.

Hybrid Buses "Ultra" Capacitors, MTA NYCT: In New York, a pilot study is underway to replace the lead-acid batteries in Hybrid Buses with long-lived and higher performance "ultra"

capacitors (10 years versus the current 3 year life). To date, the results demonstrate improved fuel economy and reduction in NOx emissions.

Lithium Ion Batteries Test, MTA NYCT: Four New York buses have been retrofitted with Lithium Ion batteries and are in service – two at MTV depot and two at Queens Village (QV) depot. The buses with lithium-ion batteries have averaged a 10% improvement in miles per gallon as compared to other hybrid buses sampled at MTV, but only about a 3% improvement over other hybrids sampled at QV. A smaller impact was expected for Queens versus Manhattan, since hybrids generally offer greater fuel savings for the lower speed, stop-and-go operations found in Manhattan than for the relatively higher speeds and less frequent stopping found in Eastern Queens.

Nitrogen in Tires, MTA NYCT: Filling bus tires with nitrogen stabilizes air pressure which leads to improved fuel economy and reduced labor cost, as well as longevity of well-filled tires. The following depots in the New York area have completed the nitrogen filling: Flatbush, Spring Creek, Ulmer Park, and Jackie Gleason. Fresh Pond Depot is currently filling its bus tires with nitrogen. The depot has a completion date of August 15, 2008. Technical Services is working with Facilities to obtain additional equipment to fill the East New York Depot in parallel with Fresh Pond.

Biodiesel Pilot Program, MTA NYCT: Portion of NYCT bus fleet has been using 5% biodiesel blend. The biodiesel pilot program began on January 29, 2008 and was concluded on July 31, 2008. There were no issues on either the bus or facility side related to the use of biodiesel fuel. Fuel samples taken from both depots have consistently been at or near the target concentration (5% biodiesel). B5 biodiesel deliveries are continuing at West Farms, College Point, Eastchester and Yonkers Depots.

more information

Calstart Program
www.calstart.org/

Lithium Ion Batteries
web.mit.edu/mitei/research/spotlights/nano-recharge.html

Modular Electric Air Conditioning
www.corp.carrier.com/www/v/index.jsp?vgnextoid=c01467617d5cc110VgnVCM100000cb890b80RCRD&vgnextchannel=c6f87afdef677010VgnVCM10 0000cb890b80RCRD&vgnextfmt=default

NREL Hydrogen and Fuel Cells Research
www.nrel.gov/hydrogen/

AC Transit fuel cell buses
www2.actransit.org/environment/hyroad_main.wu?PHPSESSID=c2b65ec9541293740edf7 a63b3746e49

4.3 GUIDELINE 4

Rail Rolling Stock Design

principles

- Innovative approach
- Conserve energy
- Renewable energy source
- Optimize energy efficiency

recommendation

- Conserve energy through innovative, more efficient railcar design.
- Use lighter weight railcars that incorporate innovations such as lighter-weight wheels, fewer motors, and lighter-weight HVAC systems. Lighter weight train cars decrease the amount of energy required to move the train.
- Use innovative designs such as improved propulsion systems, which allow for the reduction of traction motors per train car to save vehicle weight.
- Use trains equipped with regenerative braking systems. Fleet can be retrofit during a midlife overhaul
- Consider using a system which stores regenerated electricity in either a wayside or on-vehicle storage unit.

context

Improved operations can reduce energy consumption and reduce emissions.

measurement

- ***Outcome: R*** educed energy consumption
- ***Output:*** Implement technologies that reduce energy consumption
- ***Indicator:*** reduced energy consumption
- ***Target:*** improved fleet operations to reduce energy consumption
- Qualifying energy savings due to introduction of energy saving technologies.
- Quantifying Vehicle Miles Traveled (VMT) reduction due to transit ridership expansion:
- The objective is to identify how much carbon was avoided due to growth in ridership
- Two scenarios could be run:

- A scenario with transit demand capped to Year XXXX levels (i.e., what if transit did not grow beyond year XXXX levels?)
- Year XXXX "actual" scenario (i.e. what actually happened?)

- Results of two scenarios compared to establish incremental:
  - Automobile vehicle trips
  - Automobile vehicle miles traveled (VMT)
  - Automobile vehicle hours traveled (VHT)

case studies

Stationary Energy Storage System, Sacramento Regional Transit District: The California Energy Commission (CEC) and Sacramento Municipal Utility District (SMUD) provided a $400,000 grant for the installation of a stationary energy storage system on the Sacramento Regional Transit District (RT) system. The project will demonstrate the first mass transit implementation in the U.S. of cutting-edge technology that can save on energy use, provide voltage stabilization, improve service reliability, and lower operational costs and

maintenance. The energy storage technology known as Sitras SES already installed in other mass transit networks in Europe and China uses ultra-capacitors to store the potential energy released during regenerative braking and then feeds this energy into accelerating vehicles thus resulting in peak power demand reduction, energy savings and a boost to the line voltage. The system has the potential to save RT about $25,000 a year in avoided electricity costs. After this pilot's success, Sacramento RT will be able to install several more Sitras SES units for greater savings and improved system operation.

The many environmental benefits include:

- Conservation of energy
- Reduced energy cost
- Renewable energy source

Regenerative Braking, MTA NYCT: The New Technology subway car fleet (AC propulsion) is equipped with regenerative braking; however, the current operation is such that it can have an adverse effect on NYCT older car speeds if the process is not appropriately optimized. An optimization study is now underway by the agency, in collaboration with the New York Power Authority, to determine what specific improvements can be made on the existing regenerative braking systems of our current AC propulsion fleet. In addition, a parallel study is evaluating whether various wayside energy storage technologies (e.g. flywheels, capacitors, batteries, etc.) would be beneficial to NYCT. Wayside energy storage technology can store regenerative braking energy during periods of non-receptivity for use at a later time. Currently regenerated power is being utilized as "hotel power" inside our regenerating train cars for lights and HVAC.

more information

Sacramento RT SES Project
www.mobility.siemens.com/usa/en/pub/press/press_releases/press_2007/2007/7_17_2007.htm

NYCT – MTA – Sustainability Program
www.mta.info/environment/

Retrofit for regenerative breaking

33% reduction Bilbao, Spain.

May 2003, the International Association of Public Transport (UITP) Charter for Sustainable Development

ambient environment & health

Intent & Scope

This section provides guidelines for 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.

guidelines

Three guidelines are provided for Ambient Environment & Health under Rolling Stock & Fleet and are discussed in more detail in the following subsections:

guideline 1: Inviting Space

guideline 2: Bus Specific Experience

guideline 3: Rail Specific Experience

4.4 GUIDELINE 1

Inviting Space

principles

- Positive rider experience
- Reduced auto use
- Strengthen community
- Reduce stress
- Making transit fun

recommendation

Quality of Riding Experience Within Vehicles/Vessels: Provide a welcoming atmosphere and convey a sense of quality service. Once on a train or bus, riders should find a basic level of environmental comfort, such as seasonal heat or cooling, ventilation, and lighting levels that enable reading and good visibility. They should also feel safe.

- Vehicles/vessels should be clean, free of litter, unpleasant odors, and graffiti.
- Low floor buses to allow ease of passenger loading/unloading and reducing dwell time at bus stop
- Control noise and vibration.
- Lighting levels and fixtures should be functional and aesthetic, to provide good visibility and additional security.
- Maintain thermal comfort. Recommended zone ranges from X-Y degrees.
- ADA compliance improves experience for mobility/visual/hearing impaired
- Multiple doors and repeated door opening results in more air changes than in a stationary design. Alternatively, provide other means of changing air.
- 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.

context

Transit vehicles and vessels must be inviting to maintain and increase the number of people who choose to take transit.

measurement

- ***Outcome:*** Make riding transit vehicles/vessels an enjoyable experience, increasing the number of individuals who choose to take transit.
- ***Output:*** Document incorporation of rider experience into fleet design and/or selection. Survey riders on satisfaction with ambient environment within vehicles/vessels.
- ***Indicator:***
- Percentage of riders who report satisfaction with atmosphere on transit vehicles/vessels.
- Percentage of vehicle/vessel designs or procurements that add amenities to improve ambient environment for rider.
- ***Target:***
- X% or riders report satisfaction with atmosphere on transit vehicles/vessels.
- X% vehicle/vessel designs or procurements that add amenities to improve ambient environment for rider.
- X% increase in ridership

case studies

MTA NYCT's New Millennium Trains (NMT) have more efficient HVAC equipment because they use variable speed compressors to match the cooling provided with the monitored heat load. Not only this reduces the power used by HVAC systems during non-peak ridership periods, it also greatly improves riders' comfort by providing just appropriate amount of cooling. The NMT also use LED lighted displays to inform passengers about the route and other things important. (www.mta.info/nyct/facts/ffenvironment.htm)

4.4 GUIDELINE 2

Bus Specific Experience

principles

- Positive rider experience
- Reduced auto use
- Strengthen community
- Reduce stress
- Making transit fun

recommendation

- Branding and livery encourages new attitude towards bus riding
- "Rail like" and "specialized" bus designs attract new riders
- Bike rack inside the bus adds more security
- Rear facing wheelchair position is more easily secured
- Kneeling buses allow access for mobility impaired

context

Transit buses must be inviting to maintain and increase the number of people who choose to take transit.

measurement

- ***Outcome:*** Make riding transit buses an enjoyable experience, increasing the number of individuals who choose to take transit.
- ***Output:***
- Document incorporation of rider experience into fleet design and/or selection. Survey riders on satisfaction with ambient environment within buses.
- Survey ADA and bike passengers on satisfaction with designs.
- ***Indicator:***
- Percentage of riders who report satisfaction with atmosphere on transit buses.
- Percentage of bus designs or procurements that add amenities to improve ambient environment for rider.
- ***Target:***
- X% or riders report satisfaction with atmosphere on transit buses.
- X% bus designs or procurements that add amenities to

improve ambient environment for rider.

- X% increase in ridership

case studies

The FTA's BRT initiative investigates the technologies and advanced operational capabilities of BRT systems and facilitates the implementation of successful BRT projects throughout the United States. The ***Regional Transportation Commission of Southern Nevada (RTC)*** in Las Vegas, Nevada, currently operates the only "specialized" Bus Rapid Transit (BRT) vehicle in the United States. The vehicle used the MAX Civis, a European styled vehicle. Its route features station platforms that match the low-floor vehicle design. Revenue service began July 2004. This FTA demonstration project was immediately successful with a 280% increase in ridership in the first year of implementation.

New corridors are being developed to start operation in 2009. To support these new corridors, the RTC has procured a new (50) bus fleet of "specialized" BRT diesel hybrid vehicles, the Wright Streetcar. One of RTC's key objectives of this vehicle was to be visually attractive and aesthetically appealing with a vehicle that does not look like a standard bus, but is more "rail-like" in appearance. Following the success of the MAX demonstration the RTC expects these new Wright vehicles to maximize the potential for attracting new transit riders away from their cars. The key strategy in achieving this goal is to transfer attributes and technologies of rail service to bus service. The most important of these attributes are appearance and branding that will identify the service as high quality by calling attention to vehicle style and design.

RTC's choice of rail-like vehicle for its new BRT corridor goes hand-in-hand with brand identifiers such as distinctive product names, logos, taglines, slogans, color schemes, and livery designs as well as advertising through visual and other media. An identity separate from other transit services can be a successful strategy because of market differentiation as a premium service, and thus increased appeal to choice riders. In effect, BRT can establish itself as a new and distinct transit mode and enhance its competitiveness in a particular travel market with highly visible, unique design features. Low

emissions systems enhance the environmental image of BRT. Hybrid-electric drive systems offer improved performance and fuel economy with reduced emissions transit authorities are testing other fuels such as bio-diesel, engine fueled by ultra low-sulfur diesel (ULSD).

The many environmental benefits include:

- Reduced auto use
- Conserve energy
- Reduce emissions
- Optimize energy efficiency

more information

RTC ACE Rapid Transit Project
www.rtcsouthernnevada.com/mpo/downtownconnector/

4.4 GUIDELINE 3

Rail Specific Experience

principles

- Positive rider experience
- Reduced auto use
- Strengthen community
- Reduce stress
- Making transit fun

recommendation

- Consider adding amenities such as power outlets for laptops and WiFi (wireless wide area) internet access.

context

Having WiFi access and power outlets will attract more riders

measurement

- ***Outcome:*** Make riding rail transit an enjoyable experience, increasing the number of individuals who choose to take transit.
- ***Output:*** Survey riders that take transit and use WiFi
- ***Indicator:*** Increase in riders that use WiFi
- ***Target:*** X% increase in riders using WiFi

case studies

High-speed WiFi service, BART: A Sacramento company, WiFi Rail Inc., has finalized a 20-year agreement with BART to provide high-speed WiFi service on the Bay Area Rapid Transit system.

WiFi Rail has been testing the service for the past year in four downtown San Francisco stations, where more than 15,000 customers registered to use it. The service has been free during the testing.

Now that testing is complete, WiFi Rail enters Phase 2 of its rollout, which will extend service through more of San Francisco and Oakland and through the TransBay Tube. Access will remain free during Phase 2, which is expected to be completes by midyear 2009.

more information

Wireless Systems in Transit Applications, BART WiFi
www.bart.gov/news/articles/2009/news20090202.aspx
www.dailywireless.com/features/transit-offers-free-wifi-051707/

emission & pollution reduction

Intent & Scope

This section provides guidelines for reducing greenhouse gas air emissions and potential contributions of the transit system's rolling stock/fleet to air pollution, considering over-reliance on fossil fuels. When appropriate, the guidelines are developed to address specific modes, including bus, ferry, and rail.

Reference Standards

GHG Emissions Measurement: The World Resources Institute Greenhouse Gas Protocol (GHG Protocol) is the most widely used international standard for the quantification of greenhouse gas (GHG) emissions. The Protocol has worked with businesses, governments, and environmental groups around the world to develop a transparent, consistent, and credible framework for measuring and managing emissions. The Protocol Initiative has led to the creation of a suite of GHG calculation tools.

A complete listing of all tools provided by the GHG Protocol can be found at: www.ghgprotocol.org/calculation-tools/all-tools

guidelines

Two guidelines are provided for Emission & Pollution Reduction under Rolling Stock & Fleet and are discussed in more detail in the following subsections:

guideline 1: Measure and Reduce GHG Emissions from vehicle operation

guideline 2: Reduce diesel use in bus operations

4.5 GUIDELINE 1

Measure and Reduce GHG Emissions from Vehicle Operation

principles

- Alternative Technologies and Fuels
- Collaboration
- Measurement
- Data comparison
- Evaluation
- Resulting Actions

recommendation

- Many of the measures recommended and case studies cited for energy savings also reduce emissions and pollution. Baseline GHG emissions should be measured and GHG emissions following changes to vehicle operations calculated for comparison.

context

Measuring and reducing GHG emissions will make transit more sustainable

measurement

- ***Outcome: R*** educed GHG emissions from transit
- ***Output: E***stablish measurement of baseline levels of GHG emissions and improvements made by improved technologies and operational procedures
- ***Indicator:*** reduced GHG emissions
- ***Target:*** X% reduction in GHG emissions

case studies

The South Coast British Columbia Transportation Authority (TransLink)'s Bus Technology and Alternative Fuel Demonstration Project allowed TransLink to gain experience and knowledge of bus and alternative fuel technologies that reduces exhaust emissions from its bus fleet. Relevant data on the emissions, operating performance and costs of different technologies in actual operation within TransLink's service area was collected through the project and was used to guide decision making for bus fleet procurements, equipment retrofit programs and use of alternate fuels, in accordance with TransLink's Emissions Policy.

Collaborating with test consultants from MJ Bradley in Boston and emissions technologists from Environment Canada, TransLink has completed three phases of the project with state-of-the-art emissions measurement equipment. Phase one of the project commenced in 2005.

Clean diesel engines with and without particulate filters, trolley buses, various compressed natural gas engines (CNG), hydrogen compressed natural gas fuel (HCNG), different fuel blends of bio-diesel, and series and parallel diesel-electric hybrid drives were among the technologies and alternative fuels tested in the project. Carbon dioxide (CO2), carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (HC), methane (CH4), and particulate matter (PM) emissions from the buses were monitored.

Test Buses

On Board Emissions Monitoring Equipment

Exhaust Flow Meter

Of the buses tested, the trolley buses were found to be the cleanest. CO2 and NOx emissions from trolley buses are over 95% lower than that of diesel, CNG, and hybrid buses knowing that 94% of electricity in British Columbia is produced by hydroelectric facilities, which produces barely any emissions. Energy consumption of the buses were also monitored and hydroelectric energy used by the trolley buses appeared to be both environmentally and cost friendly as the energy cost for trolley buses during the test was $0.44/km lower than diesel buses.

Other notable results from the project include:

- The diesel-electric hybrid bus in phase 1 produced the lowest g/km of green house gases (GHG); up to 500g/km less than the other buses.
- The diesel-electric hybrid bus from phase two has the lowest HC, CO2, and CO emissions on supplemental cycles as well as the lowest propulsion and non-propulsion related maintenance costs compared to the CNG and diesel buses tested in phase 2.
- The use of bio-diesel instead of diesel fuel in buses lowers GHG emissions
- Diesel buses equipped with particulate filters

significantly reduce particulate matter emissions (by over 1 gram/km traveled) compared to diesel buses without filters.

Using results from the project, TransLink showed its commitment to environmental leadership and good environmental stewardship through purchasing 188 standard and 40 articulated trolley buses from 2005-2008, changing the fleet's standard petroleum based diesel fuel to B5 and B20 bio-diesel fuel in 2007, and began retrofitting all 2001 and earlier diesel buses with particulate filters.

Trolley Bus

In 2009, TransLink plans to purchase 34 additional articulated trolley buses as well as 236 diesel-electric hybrid buses to further reduce fleet emissions.

Realtime Traffic Flow Management (RTFM) scenarios were developed to test the effectiveness of specific policy changes to estimate the modal diversion from private automobile to transit or other modes. For each scenario tested, detailed estimates of diversions of vehicle trips, vehicle-miles of travel and vehicle-hours of travel were calculated. The model diversion results are to be used to estimate carbon reduction. Policies can be tested, for example, to see if they reduce carbon within a service area. Examples of policy scenarios which could be tested include:

- Transit fare policy
- Transit level-of-service (where additional service can be accommodated)
- Automobile tolls/pricing
- Parking costs
- SOV restrictions

Carbon Reduction Analysis should be performed to evaluate the potential regional carbon savings associated with future policy and technology changes.

more information

Davis, T. and M. Hale (2007). Public Transportation's Contribution to U.S. Greenhouse Gas Reduction. McLean, Virginia, Report for American Public Transportation Association and Transportation Research Board.

Translink Clean Fuel Program

www.translink.bc.ca/About_TransLink/News_Releases/news06210701.asp

IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 3: Industrial Processes and Product Use. www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.htm

UNFCCC, AM0031 for Bus Rapid Transit

4.5 GUIDELINE 2

Reduce Diesel Emissions in Bus Operations

principles

- Alternative Technologies and Fuels
- Collaboration
- Measurement
- Data comparison
- Evaluation

recommendation

- Consider using renewable or alternative fuels. Appropriateness of various fuels depends on agency specific conditions, such as weather conditions, fuel availability and route type. Alternative fuels that may be appropriate for your fleet include fuel additives and conditioners, bio-diesel, CNG and LNG, LPG, diesel and water mixtures, Dual fuel (diesel and natural gas), Fischer-Tropsch, Coal-To-Liquids (CTL), Gas-To-Liquids (GTL) or Biomass-To-Liquids (BTL), Methanol and Ethanol, Hydrogen and ultra-low sulfur diesel.

context

Reduced usage of diesel fuel and replacement with alternative fuels will reduce dependence on oil, reduce emissions and convert to sustainable fuels for transit.

measurement

- ***Outcome: R*** educed emissions from transit buses and reduced dependence on oil
- ***Output: E***stablish measurement of baseline levels of emissions and petroleum based fuel usage and improvements made by improved technologies and the use of alternative fuels
- ***Indicator:*** reduced emissions and reduced diesel fuel consumption
- ***Target:*** X% reduction in emissions and diesel fuel use

case studies

Biodiesel, AC TRANSIT: Biodiesel is a cleaner-burning alternative to traditional diesel that can be produced from a variety of plant materials. In addition to potentially reducing overall carbon emissions, biodiesel offers the opportunity to reduce dependence on foreign oil.

AC Transit is test-driving B20, a blend of 20% biodiesel and 80% petroleum diesel in a portion of its fleet. The advantage of B20 over using 100% biodiesel (B100) is that B20 can be used with AC Transit's existing diesel engines, with minimal modifications to fuel systems or refueling infrastructure.

GTL is a liquid fuel derived from natural gas, rather than from crude oil. Natural gas is cleaner and more abundant than petroleum, but harder to transport, simply because it's a gas. Converting the gas to liquid solves that problem. As opposed to using compressed natural gas (CNG) as a fuel, GTL requires few, if any, modifications to existing diesel engines.

As with biodiesel, AC Transit is conducting a six-month trial to evaluate performance, efficiency and environmental issues. By testing biodiesel and GTL in the real world, AC Transit will gain invaluable operational experience. Proving efficacy and reliability are critical first steps in encouraging further development of alternative fuels.

Fuel cell buses are clean, quiet, electrically propelled vehicles that emit only water vapor from the tailpipe.

Since 2000, AC Transit has been developing what has become the most comprehensive hydrogen fuel cell demonstration program in the world, featuring:

- Three zero-emission hybrid-electric, hydrogen fuel cell buses
- A fleet of fuel cell passenger vehicles
- On-site hydrogen production and fueling
- On-site fleet maintenance
- Ongoing, outside evaluation
- Public education and safety training

The HyRoad aims to demonstrate the viability of an emission-free transit system.

Biodiesel, MTA Bridges and Tunnels Fleet: MTA is also using bio-diesel. Its bio–diesel is manufactured from

domestically produced oils such as soybean or recycled cooking oils and blended with ultra–low sulfur diesel. Using bio–diesel fuel in conventional diesel engines has a positive impact on the environment, with substantial reduction emitted into the air of unburned hydrocarbons, carbon monoxide and particulate matter-the "carbon footprint." By using alternative fuels such as E–85 (a mix of ethanol and gasoline) and bio–diesel and by procuring flex–fuel and electric hybrid vehicles, the agency reduced its carbon footprint last year, and that percentage will only rise as older vehicles are replaced going forward.

Of the agency's light–duty (8,500 lbs. or less) fleet, 119 vehicles out of 185 (64.3%) are now using E–85 or are hybrid–electric. Plans for 2009 include replacement of an additional 28 gasoline–fueled cars with alternate fuel vehicles, bringing the agency's overall light–duty fleet to more than 80% alternate fuel.

more information

AC Transit Programs
www.actransit.org/environment/exploring_alternatives.wu

MTA Bridges and Tunnels Fleet
www.mta.info/mta/news/releases/?en=081014-BT1

5 operations & maintenance

introduction

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; greenhouse gas emission reductions including the reduction and conservation of petroleum fuels; use of renewable energy; energy efficiency; pollution prevention; hazardous materials management; waste reduction and recycling; and responsible purchasing.

The following guidelines are provided in this section, Operations & Maintenance:

5.1 System Planning, Land Use and Site Design

Guideline 1: Siting of Fueling Facilities

Guideline 2: Placement of Power Sub-stations

5.2 Materials

Guideline 1: Paint and Solvents

Guideline 2: Manage Waste Water

Guideline 3: Recycle refrigerant, oil, engine coolant and batteries

5.3 Energy

Guideline 1: Improve Energy Efficiency of Operations & Lower Peak Demand

Guideline 2: Use Renewable Energy Resources

Guideline 3: Energy Conservation

Guideline 4: Bus Operations & Maintenance

Guideline 5: Ferry Operations & Maintenance

Guideline 6: Rail Operations & Maintenance

5.4 Ambient Environment & Health

Guideline 1: Crowd Control and Riding Comfort

Guideline 2: Provide Clean and attractive vehicles and stations

Guideline 3: Provide Friendly and Courteous Operators

5.5 Emissions & Pollution Reduction

Guideline 1: Pollution Reduction Strategies

Guideline 2: Enhance Facility Performance and Longevity

system planning, land use & site design

Intent & Scope

This section provides guidelines that 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.

guidelines

Two guidelines are provided for System Planning, Land Use and Site Design under Operations & Maintenance and are discussed in more detail in the following subsections:

guideline 1: Fueling Facilities Siting

guideline 2: Placement of Power Sub-stations

5.1 GUIDELINE 1

Fueling Facilities Siting

principles

- Reduced Fuel Usage
- Measurement
- Data comparison
- Evaluation

recommendation

- Evaluate the location of fueling sites for buses in relationship to the routes being planned

context

Reduction of dead head time will reduce fuel usage

measurement

- ***Outcome: R*** educed fuel consumption
- ***Output: E***stablish estimates of fuel usage based upon the siting of the fueling facility.
- ***Indicator:*** reduced diesel fuel consumption
- ***Target:*** X% projected reduction in diesel fuel use for selected site

case studies

AC Transit HyRoad: Commercialization of Fuel Cells for Public Transit—Accelerated testing to failure (partial phase 1) of existing fuel cell buses (WestStart-CALSTART)

more information

NREL Siting a Hydrogen Fueling Station
www.nrel.gov/docs/fy08osti/42781-1.pdf

5.1 GUIDELINE 2

Placement of Power Sub-stations

principles

- Reduced Power Usage
- Measurement
- Data comparison
- Evaluation

recommendation

- Evaluate the location of power sub stations for rail projects in relationship to the routes being planned

context

Reduction of power losses will reduce power consumption and the placement of the sub station can reduce capitol and operating costs

measurement

- ***Outcome:*** Reduced power consumption and costs
- ***Output:*** Establish estimates of power usage, construction and operating costs based upon the siting of the power sub stations
- ***Indicator:*** Reduced power consumption and costs
- ***Target:*** X% reduction in power consumption and costs for selected sites

case studies

The installation of new streetcar and electric trolley bus (ETB) systems in dense urban areas poses some design challenges which are not usually seen in rapid transit or LRT systems. Streetcars and ETBs operate almost exclusively in dense urban areas, while rapid transit and light rail normally operate with long open route sections and brief forays into downtown areas. The usual strategies employed with LRT systems—namely, providing power from the fringes of the downtown area with a low impedance distribution system and relocation of all utilities in the affected streets—are difficult and very expensive to implement on an exclusively urban system. In the Northwest, the Portland (Oregon) Streetcar and Seattle (Washington) Metro ETB systems have used some innovative strategies to address these challenges.

more information

Traction Power Design Considerations
onlinepubs.trb.org/Onlinepubs/circulars/ec058/14_01_Collins.pdf

materials

Intent & Scope

This section provides guidelines for specifying and using materials applying concepts of appropriate life-cycle analysis, increased length of use, potential for reuse/recycle, and reduction of toxics.

Reference Standards

Green Seal: Green Seal is an independent non-profit that establishes standards to promote the manufacture, purchase, and use of environmentally responsible products. Several of these standards are relevant for transit operations including those for paints and coatings and for vehicle fleet operations. These standards can be found at: www.greenseal.org/certification/environmental.cfm

guidelines

Three guidelines are provided for Materials under Operations & Maintenance and are discussed in more detail in the following subsections:

guideline 1: Paint and Solvents

guideline 2: Manage Waste Water

guideline 3: Recycle refrigerant, oil, engine coolant and batteries

5.2 GUIDELINE 1

Paint and Solvents

principles

- Reduced Toxic Waste
- Measurement
- Data comparison
- Evaluation

recommendation

- Utilize low VOC and water based paints and solvents

context

Utilizing low VOC and water based paints and solvents will reduce the amount of toxic waste to be managed by maintenance

measurement

- ***Outcome:*** Reduced toxic waste
- ***Output:*** Establish baseline of toxic waste being disposed of and measure the amount of reduction using new paints and solvents
- ***Indicator:*** Reduced quantities of toxic waste
- ***Target:*** X% reduction in toxic waste

more information

Low VOC Paint
www.eartheasy.com/live_nontoxic_paints.htm

corporateportal.ppg.com/NA/Refinish/PPGRefinish/2-0-Products/050_Envirobase/EN

5.2 GUIDELINE 2

Manage Waste Water

principles

- Reduced Waste Water
- Measurement
- Data comparison
- Evaluation

recommendation

- Recycle vehicle wash waste water and storm drain run off

context

Reduction of waste water is good for the environment

measurement

- ***Outcome:*** Reduced waste water
- ***Output:*** Establish baseline of waste water and storm drain run off and measure improvements
- ***Indicator:*** Reduced waste water and storm drain run off
- ***Target:*** X% reduction in waste water and storm drain run off

case studies

Phase II Storm Water Management Program (SWMP) has been prepared by the ***Metropolitan Transportation Authority (MTA) Metro-North Railroad (MNRR)*** for its facilities. The aim of this program is to control storm water runoff discharges from a number of facilities to the waters of the United States in accordance with the requirements of the United States Environmental Protection Agency (USEPA) The aim of the Clean Water Act, the federal Phase II storm water regulations and the program proposed in the MNRR SWMP is to reduce to the "maximum extent practicable" pollutants in storm water discharges

Also refer to 3.5 Guideline 2: Water in this document.

more information

MTA New York Storm Water Program
www.mta.info/mnr/html/stormwater.htm

5.2 GUIDELINE 3

Recycle Refrigerant, Oil, Engine Coolant and Batteries

principles

- Reduced waste products by recycling
- Measurement
- Data comparison
- Evaluation

recommendation

- Reduced refrigerant, oil, engine coolant and batteries waste products by recycling

context

Reduction of waste products by recycling will be more sustainable and reduce toxic chemicals in land fill (and subsequently reduce toxic chemicals in ground water).

measurement

- ***Outcome:*** Reduced waste products and recycled waste products
- ***Output:*** Establish measurements of waste products and track the reduction in waste as the program is implemented
- ***Indicator:*** Reduced in waste products
- ***Target:*** X% reduction in waste products

more information

Seattle King County Transit Recycle Program:
transit.metrokc.gov/prog/recycle/re-facts.html

New Jersey Transit Recycle Program
www.njtransit.com/tm/tm_servlet.srv?hdnPageAction=PressReleaseTo&PRESS_RELEASE_ID=2207

NYMTA Recycle Program
www.mta.info/nyct/facts/ffenvironment.htm#aru

energy

Intent & Scope

This section provides guidelines for reducing energy consumption in transit operations and maintenance, investigating ways to improve energy efficiency and identifying what renewables might work for various operations and maintenance activities within the system. When appropriate, the guidelines address specific modes, including bus, ferry, and rail.

guidelines

Six guidelines are provided for Energy under Operations & Maintenance and are discussed in more detail in the following subsections:

guideline 1: Improve Energy Efficiency of Operations & Lower Peak Demand

guideline 2: Use Renewable Energy Resources

guideline 3: Energy Conservation

guideline 4: Bus Operations & Maintenance

guideline 5: Ferry Operations & Maintenance

guideline 6: Rail Operations & Maintenance

5.3 GUIDELINE 1

Improve Energy Efficiency of Operations & Lower Peak Demand

principles

- Reduced energy consumption
- Measurement
- Data comparison
- Evaluation

recommendation

- Utilize energy saver and hibernate function on motors and equipment
- Staff training: include energy and efficiency requirements into operation of vehicle
- Monitor vehicle consumption: Agency's finance department keeps track of all fuel being used every day. This department can provide information regarding fuel consumption per bus, incentive for lowest fuel, individual accountability, and need to use energy responsibly
- Work with unions in some cases
- Reduce idling
- Reduce ownership and operation of non-revenue vehicles: Consider participating in car sharing organizations such as Zip Car or City Car Share instead of owning a fleet of non-revenue vehicles. Transit agency support as a major customer can encourage more car sharing and agency can encourage car sharing organizations to get more hybrids.
- Establish policies regarding location of meetings, avoiding unnecessary trips, and right sizing vehicles.
- Utilize telephone or web-based meetings and training sessions whenever possible.

context

Reducing energy use by reducing demand and operating more efficiently provide a more sustainable

measurement

- ***Outcome:*** Reduced energy consumption
- ***Output:*** Measure baseline energy consumption and

the impacts of the programs implemented

- ***Target:*** Reduced energy consumption
- ***Indicator:*** X% reduction in energy consumption

more information Look at Canadian program called Smart Drive Training

5.3 GUIDELINE 2

Use Renewable Energy Resources

principles

- Increased Use of Renewable Energy Sources
- Reduced energy consumption
- Measurement
- Data comparison
- Evaluation

recommendation

- Purchase electricity generated from renewable sources to power daily electricity needs. Contact your utility to learn about options available in your area.
- Purchase Renewable Energy Credits.
- Implement various renewable energy projects outlined elsewhere in these Guidelines.

context

Using renewable energy reduces dependence on oil and is sustainable

measurement

- ***Outcome:*** Increased use of renewable fuels
- ***Output:*** Measure current use of renewable fuels and the increased use once the program is in effect
- ***Target:*** Increased use of renewable fuels
- ***Indicator:*** X% increased use of renewable fuels

more information

Information on Biodiesel Fuels
www.biodiesel.org/

5.3 GUIDELINE 3

Energy Conservation

principles

- Reduced energy consumption
- Measurement
- Data comparison
- Evaluation

recommendation

- Install signal to let operators or occupants know that doors are open to conserve heat/cooling. Be accountable for energy used year by year - performance measure for facility operator and owner/maintainer
- When replacing lighting, use fluorescent lamps including both thin tubes and CFLs for tunnel lighting, station lighting, etc, and Light Emitting Diode (LED) lights (in signals, emergency lights, signage, etc.).
- Use motion sensors and photoelectric dimmers in ancillary rooms and other remote work areas to reduce electricity consumption.
- Use photocells and timers to control exterior lighting fixtures.
- Incorporate microprocessor-based lighting control and power reduction system to increase or decrease voltage to minimize power consumption.

context

Reduced energy use reduces dependence on oil and is sustainable

measurement

- ***Outcome:*** Reduced energy consumption
- ***Output:*** Measure baseline energy consumption and the impacts of the programs implemented
- ***Target:*** Reduced energy consumption
- ***Indicator:*** X% reduction in energy consumption

case studies

Energy Management System, MTA NYCT: The energy system at the MTA NYCT's Corona Shop includes natural gas, fuel, solar power, and fuel cell power and is designed to exceed the New York State Energy Code by 36%. An energy

management system tallies and trends energy usage at the facility so that operating staff can change operating modes/conditions as appropriate. During on-going operation, train and empower staff to make and suggest operating changes that would benefit the overall sustainability of the system.

more information

MTA Energy Saving Program:
www.mta.info/nyct/facts/ffenvironment.htm

5.3 GUIDELINE 4

Bus Operations & Maintenance

principles

- Increased Use of Renewable Energy Sources
- Reduced energy consumption
- Measurement
- Data comparison
- Sustainability - CAC emission reduction, economical
- Zero disruption to service

recommendation

- Alter bus operations and routes based on optimized energy usage (computer model).
- Tailor preventive and other maintenance to minimize energy usage – By developing an efficient maintenance program shop tools and lifts can be used optimally thereby reducing energy consumption

context

Reduced energy use reduces dependence on oil and is sustainable

measurement

- ***Outcome:*** Reduced energy consumption
- ***Output:*** Measure baseline energy consumption and the impacts of the programs implemented
- ***Target:*** Reduced energy consumption
- ***Indicator:*** X% reduction in energy consumption

5.3 GUIDELINE 5

Ferry Operations & Maintenance

principles

- Increased Use of Renewable Energy Sources
- Reduced energy consumption
- Partnering (internal)
- Sustainability - CAC emission reduction, economical
- Zero disruption to service

recommendation

- Tailor preventive and other maintenance to minimize energy usage – By developing an efficient maintenance program shop tools can be used optimally thereby reducing energy consumption

context

Reduced energy use reduces dependence on oil and is sustainable

measurement

- ***Outcome:*** Reduced energy consumption
- ***Output:*** Measure baseline energy consumption and the impacts of the programs implemented
- ***Target:*** Reduced energy consumption
- ***Indicator:*** X% reduction in energy consumption

case studies

Principles/Guidelines, Albion Ferry: TransLink provides the "Albion Ferry" car ferry across the Fraser River in Surrey, BC. The two vessels on the run, M/V Kulleet and M/V Klatawa are each powered by two CAT 3406C mechanically-controlled diesel main engines, as well as two 25kW Deutz F32-914 diesel generators.

TransLink's environmental policy first aims to reduce overall transportation emissions in the region, and the second goal is to reduce direct emissions from TransLink's fleet. With that support, in February 2008, TransLink started a project to install Diesel Oxidation Catalysts (DOCs) on the main engines and the generators with the objective to reduce Criteria Air

Prior to Retrofit
(with Kulleet Silencer)

After Retrofitted DOC

Contaminant (CAC) emissions.

- *Work Done:* After the DOC model had been selected (based on engine type, size, and duty cycle), in advance of the DOC retrofit, a welder fabricated all the necessary fittings and brackets to install the DOCs in place of the previous mufflers. In the middle of the night in February, while the vessels were shut down for normal maintenance for a few hours, the ship's crew unbolted the mufflers, welded in new brackets, and bolted the new DOCs in place.
- *Costs:* The Silex DOCs chosen cost $53,000 for four DOCs ($12K each) and four generator DOCs ($1,250K ea). The installation performed by vessel crew during downtime on the morning one weekend; some welding and bolt-on installation required; installation and fabrication costs were $1,500 per vessel. The DOCs are not expected to require any ongoing maintenance costs, given TransLink's long experience with DOCs on transit buses.
- *Environmental Benefit:* Each vessel consumes approximately 300,000 litres of fuel per year, with the main engines spending 55% of their time at idle, and much of the rest of the time at full load.

The main engines are certified to an emissions standard similar to US EPA Tier 1 for off-road engines, which is roughly comparable to a late-1980s on-highway diesel engine. Emission measurements were not taken before or after the DOC retrofit so precise numbers aren't known, but the engines were believed to have considerable CAC emissions, including VOC (2.3 t), CO (4.6 t), and PM (2.3 t) which would be reduced with DOCs. The DOCs are expected to reduce emissions for both vessels by 70% for VOCs (1.6 tonne reduction), 80% for CO (3.7 tonne reduction), 35% for PM (0.8 tonne reduction), based on the assumed emissions factors.

Since the vessels are expected to run for about 2 years after installation of these DOCs, the cost per tonne of PM reduction

is approximately $35,000 per tonne.

After installation, it has been observed that visible smoke from the engines has been considerably reduced. It is believed that this improves public perception.

Future plans for continued use of technology/practice: A new passenger ferry is currently being built for TransLink, and has been designed with a DOC to reduce emissions. TransLink's other two passenger ferries are due for overhauls in the next year or two, at which point emissions DOC and Diesel Particulate Filters retrofits are being considered. (www.translink.bc.ca/Transportation_Services/Albion_Ferry/default.asp)

5.3 GUIDELINE 6

Rail Operations & Maintenance

principles

- Reduced energy consumption
- Measurement
- Data comparison
- Evaluation

recommendation

- Tailor preventive and other maintenance to minimize energy usage: By developing an efficient maintenance program shop tools and lifts can be used optimally thereby reducing energy consumption Track lubricant
- Communication based train control (CBTC) improves the operational efficiency of a train system because it operates the train by computer. This allows trains to be spaced closer together allowing more customers per hour, and it 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.

context

Reduced energy use is sustainable

measurement

- ***Outcome:*** Reduced energy consumption
- ***Output:*** Measure baseline energy consumption and the impacts of the programs implemented
- ***Target:*** Reduced energy consumption
- ***Indicator:*** X% reduction in energy consumption

case studies

Train to Wayside Communication: With the completion of Denver's Southeast Corridor, an electronic train announcement (Variable Message Sign) system has been installed throughout the entire RTD Light rail system. In addition, communication based train control improves the operational efficiency of a train system because it operates the train by computer. These systems allow riders to know when their buses or light rail vehicles will arrive and transit management to monitor and control location of the vehicles.

The environmental and cost savings benefits include:

- Maximizing useful passenger carrying capacity. This allows trains to be spaced closer together allowing more customers per hour, eliminating the need for additional rail infrastructure
- It helps limit the amount of energy used because the train will automatically slow down with a decreased need for electrical energy needed for braking.
- Accurate electronic train announcements result in better rider experience.

Global Positioning System (GPS) receivers and Machine-to-Machine (M2M) modems on the vehicles report location in real time to the suite of Spot Infrastructure Management Applications (SIMA). SIMA is a comprehensive, web-based collection of applications which provide a wide range of control, monitoring, configuration and management capabilities for Spot Devices systems. SIMA determines when a vehicle is approaching a stop, and notifies the Controller. The controller then activates visual or audible messages to alert waiting riders. Traffic system management personnel may access SIMA at any time by any browser-enabled device with appropriate security permission.

"The train to wayside communication system will be used for providing routing whenever there are powered switches. The signals and switches on the operator's console provide the operator information regarding the status of the route and the ability to make changes in the switch positions. This is accomplished by street imbedded loops, interrogator equipment and car-borne transponders. This enables the operator to make changes in the route quickly and safely, enabling service schedule adherence in the event of abnormal operations. This same equipment may also be utilized in the build-out of a rapid transit system to preempt traffic signals." (Sect 2:10, RTD Commuter Rail Guidelines, 9/07)

ambient environment & health

Intent & Scope

This section provides guidelines on transit system operation and maintenance practices to create a positive, safe and healthy ambient environment for patrons.

guidelines

Three guidelines are provided for Ambient Environment & Health under Operations & Maintenance and are discussed in more detail in the following subsections:

guideline 1: Crowd Control and Riding Comfort

guideline 2: Provide Clean and Attractive Vehicles, Stations, and Transit Nodes

guideline 3: Provide Friendly and Courteous Operators

5.4 GUIDELINE 1

Crowd Control and Riding Comfort

principles

- Engage the public to build support for expanded transit use
- Improve public understanding of transit and environmental principles
- Attract new transit riders

recommendation

- ***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.
- ***Control Crowds:***
- 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.
- Let riders waiting on platforms know the length of the approaching train and where trains various length trains stop along platform. With this information passengers can distribute themselves along the platform and thereby increasing their chances of quickly enter and finding a seat.
- When possible, mark platform to indicate where car entrances are located to facilitate organized queuing and easier exiting for disembarking passengers.
- ***Riding Comfort:***
- Monitor and control noise levels riders are exposed to. Monitor and control air temperature and flow. Maintain safety records and publicize successes to make riders feel safe on transit.
- Keep vehicle windows and interiors clean.
- Maintain track and wheels to reduce in-vehicle noise.

- ***Reduce Stress from Navigating:*** Announce each stop visually and verbally.

context

People are more likely to choose to ride transit if they are comfortable. Overly crowded vehicles and vessels turn people away from transit. Operators and maintenance staff must make decisions to control crowds and maximize riding comfort.

measurement

- ***Outcome:*** increase the number of people who choose to take transit by controlling crowds and proving comfortable service. Displace less sustainable modes.
- ***Output:***
- Measure current ridership and increased ridership once programs are implemented
- Crowd control measures such as hot standby vehicles to dispatch if crowd of passengers at the station or transit node is too high
- ***Indicator:*** Improved customer satisfaction, reduced complaints, increased ridership
- ***Target:*** X% increased ridership

5.4 GUIDELINE 2

Provide Clean and Attractive Vehicles, Stations, and Transit Nodes

principles

- Engage the public to build support for expanded transit use
- Improve public understanding of transit and environmental principles
- Attract new transit riders

recommendation

- Keep vehicle windows, wayfinding signage, and interiors clean and free from graffiti.
- Repair body damage and repaint when needed
- Provide periodic thorough cleaning to eliminate stains and odors, particularly elevators.

context

People are more likely to choose to ride transit if they view it as clean, attractive, and odor free

measurement

- ***Outcome:*** Increase the number of people who choose to take transit and displace less sustainable modes.
- ***Output:*** Measure current ridership and increased ridership once programs are implemented
- ***Indicator:*** Improved customer satisfaction, reduced complaints, increased ridership
- ***Target:*** X% increased ridership

5.4 GUIDELINE 3

Provide Friendly and Courteous Operators

principles

- Engage the public to build support for expanded transit use
- Improve public understanding of transit and environmental principles
- Attract new transit riders

recommendation

- Provide training to operators to be helpful and courteous and not rude. Train them to be good will ambassadors and the face of transit to the riding public.
- Enforce agency uniform standards
- Provide information to the operator on delays on road calls so they can make informed decisions about their options

context

People are more likely to choose to ride transit if they are relating to a friendly and courteous operator

measurement

- ***Outcome:*** Increase the number of people who choose to take and displace less sustainable modes.
- ***Output:***
- Measure current ridership and increased ridership once programs are implemented
- Crowd control measures (examples?)
- ***Indicator:*** Improved customer satisfaction, reduced complaints, increased ridership
- ***Target:*** X% increased ridership

emissions & pollution reduction

Intent & Scope

Pollution reduction and prevention requires close monitoring of operations and includes many facets. Training and emergency management for situations such as spills is normally part of an Environmental Management System. As described in Section 2, this type of system permits organizations to set goals for all aspects of environmental management. These aspects normally include reduction and elimination of impacts to the natural environment including spills, leaks, and air emissions.

Other areas of concern include monitoring the storage, use, and disposal of hazardous materials. Where possible, materials purchased should be evaluated to ensure that the least hazardous materials are being purchased. Hazardous materials should be tracked and systematically eliminated from use, where possible. 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 including waste prevention, and recycling. Most materials can be recycled or reused. In a transit organization, it is typical to recycle items including: 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. For example, is the waste oil being re-refined or is it being burned as fuel? Green procurement, or environmentally responsible purchasing, is valuable for establishing this type of information in a large organization.

guidelines

Two guidelines are provided for Emissions & Pollution Reduction under Operations & Maintenance and are discussed in more detail in the following subsections:

guideline 1: Pollution Reduction Strategies

guideline 2: Enhance Facility Performance and Longevity

5.5 GUIDELINE 1

Pollution Reduction Strategies

principles

- Reduced waste products
- Reduced emissions
- Measurement
- Data comparison

recommendation

- Methods that extend life of lubricants
- Reduce pesticide and herbicide use. Utilize Integrated Pest Management. Refer to EPA's Integrated Pest Management program at www.epa.gov/pesticides/
- Vehicle washer water use reduction through system design for recycling.
- Operational waste reduction and recycling programs, such as recycling of railroad ties, electronic devices, lamps, and ballasts.
- Recycle magnetic ballasts and older fluorescent lamps containing poly-chlorinated biphenyls (PCBs) and other toxic chemicals in such a manner that potentially dangerous chemicals are safely reprocessed. Recycle HID lamps.
- Recycle paper products, bottles, cans, and compostable materials such as landscape and food waste.

context

Reducing pesticide use, recycling bus wash water, and extending the life of lubricants will reduce the amount of toxic waste to be managed by maintenance

measurement

- ***Outcome:*** Reduced toxic waste
- ***Output:*** Establish baseline of toxic waste being disposed of and measure the amount of reduction using new paints and solvents
- ***Indicator:*** Reduced quantities of toxic waste
- ***Target:*** X% reduction in toxic waste

case studies

Bioinfiltration Cell/Rain Garden, MARTA: Atlanta's MARTA Landscape Architects designed and oversaw the construction

of a Bioinfiltration Cell/Rain Garden in a problem area at the Oakland City Station. The area in question is not only highly visible to patrons, but is also a key access for maintenance personnel. After heavy rain events, a large puddle would sit in this low spot for days. Sediment accumulated on the walkway, and washed into an existing catch basin. The construction began February 25, 2008, and was completed on February 28. Planting was delayed until the end of March. As part of the project, informational signs were posted to educate patrons about what was being constructed. Environmental benefits of bioinfiltration include reduction of Total Suspended Solids by 80%; reduction of excess phosphorus and nitrogen by 50%-60%; reduction of heavy metals by 80%; allowing storm water to recharge aquifers, rather than running off. The basic principle is to use the landscape as Green Infrastructure to slow down, allow infiltration of, and treat storm water. In addition to environmental benefits, properly designed bioinfiltration systems can reduce the cost of site development by requiring fewer, smaller storm sewers, and by maximizing the use of disturbed land.

This project demonstrated the following:

- Advocacy – demonstration project visible to the community, educational signs posted.
- Life Cycle Assessment

5.5 GUIDELINE 2

Enhance Facility Performance and Longevity

recommendation

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

6 implementation tools

Section 6, Implementation Tools, provides a toolbox with key practices, approaches, and systems that are necessary to implement the recommendations provided in previous sections. Topics include advocacy, partnering with external and internal entities, groups, and individuals, life cycle assessment, performance measurement, environmental management systems, and checklist of sustainability considerations.

These principles are referenced throughout the document as follows:

	Relevant Sections			
	2	**3**	**4**	**5**
Implementation Tools				
Advocacy: Promoting sustainability internally and to the community. Actively marketing the benefits of transit to the community.	***	***	***	***
Partnering: Building mutually beneficial relationships with a diverse group of external stakeholders and internal staff, management, board members, and others	***	***	**	**
Multiple Account Evaluation: A systematic, comprehensive evaluation method, incorporating both qualitative and quantitative costs and benefits, used to compare and assess alternate projects or initiatives	***	***	**	*
Life Cycle Assessment: A tool to evaluate and weigh 'cradle to grave' environmental impacts and costs of materials and processes	***	***	***	**
Environmental Management Systems/ Sustainability Management Systems: 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.	*	**	***	***
Measurement: Tracking how an agency is performing and documenting results	*	***	***	***

Note:
* Low Impact
** Impact
*** High Impact

advocacy

One of the primary goals of these guidelines is to displace travel by automobiles. A sustainable transit system requires high ridership, maximizing the number of people removed from their cars. Improving the public image of transit through marketing is one means to accomplish this goal. The many benefits of transit should be highlighted and the public should be provided with a positive image of traveling by transit. This approach expands the traditional role of a transit agency to go beyond providing a service. It is, however, well within the mission of most transit agencies because of the need for significant ridership. Marketing by the automobile industry glamorizes travel by car, while the many benefits of transit are often overlooked. Highlighting these benefits will help transit to more successfully compete with the automobile.

- Reframe transit by promoting its strengths. Highlight the competitive advantages of choosing transit over driving, including
- ***Save Money:*** Reduce vehicle use and ownership; consider costs such as car purchase, insurance, repairs, maintenance, gas, and parking.
- ***Safety:*** Highlight reduced safety risks from transit. Use statistics to inform the public of transit's safety records. Provide 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 and sufficient personal space.
- ***Improve Health:*** Increased physical activity from walking to stops. Clarify the health benefits associated with transit, such as comparing average air quality on a subway car and a freeway. Obtain data from Public Health Departments on the community to be served, when possible.
- ***Environment:*** Reduce greenhouse gases, other emissions linked to cancer, asthma, etc.

- ***Improve Time Management:*** Know exactly when transit will arrive and depart.
- ***Reduce Stress:*** Relax or work on trip, dependable, easy to use, no traffic or parking.
- ***Improve Quality of Life:*** Strengthen community by getting people into public spaces.
- ***Enjoyment:*** Riding transit can be a fun experience, spending more time in the community helps people feel connected.
- Specifically target the business community to explain how transit can meet their needs. Highlight the potential competitive advantages of accessibility of the workforce and businesses to transit, including:
- ***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 for commute)
- ***Added value to company facilities.***
- ***Reduce the need to build or otherwise subsidize parking.***
- ***Capture trade of transit users by locating businesses in convenient proximity to transit*** (i.e. within transit-oriented development).
- Specifically target Economic Development entities to explain how transit is an advantage to a community's economic health, by helping businesses, see above.
- Create an internal marketing group or work with a private firm. Develop a marketing strategy. Ensure the public is getting the information to make informed choices. Considering targeting youth to develop habit of traveling by transit at an early age, before the auto-dependency forms. Encourage employers to provide passes for employees. (case study – 'fish in the city' Millennium Line)

partnering

Effective partnerships are key to improving sustainability. Transit is inherently connected with the needs of stakeholders and the decisions of other organizations. Many of the guidelines recommended in this document can only be fully accomplished through partnering with external organizations. Key elements of successful partnering include:

- Generate open, early dialogue
- 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.[4]

external partnerships

- Utilize public participation to optimize things such as alignment selection and development and build support for use and maintenance of transit. Utilize input from representatives of a broad cross-section of the community.
- 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.

4 Including, for example, the following: Provide copies of meeting minutes to agency and partners; distribute copies of signed agreements between transit agency and partners, and include graphic documentation as mutually developed and agreed upon.

- 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.
- Ensure early dialogue with 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.
- Work with state 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 state and local jurisdictions. Authorities and agencies to consider include:

Examples of State agencies:	**Examples of Local agencies (City, County, other):**
Dept. of Transportation	Dept. 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

internal partnerships

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. Recruit representatives from each division to fully participate in developing and updating the program. Provide the program with appropriate funding and resources for education, training, and performing outreach functions. Working with Agency communications team, schedule and execute appropriate sustainability awareness programs. Create measurements and reporting of sustainability initiatives across the agency, and share these results with outside partners and the general public.[5]

multiple account evaluation

Multiple Account Evaluation (MAE) is a systematic, comprehensive evaluation method, incorporating both qualitative and quantitative costs and benefits, used to compare and assess alternate projects or initiatives. The benefits and costs are assessed over the expected useful life of the project. The evaluation is based on the perspective of everyone who is affected and their values and preferences. Benefits are any positive consequences that people are willing to pay for and costs are any negative consequence that people must be compensated for to willingly supply or accept.

Typical accounts evaluated in transit projects include Financial, Social/Community, User Benefits and Environmental. Financial

5 Submittals may include: Copies of meeting minutes; copies of signed internal partnering agreements between Agency Sustainability Team representatives; and reports documenting ongoing results of sustainability efforts along with performance measurements and recognizing noteworthy participants.

benefits are usually the direct incremental costs and revenues associated with a project or initiative. The Social/Community account most often uses qualitative descriptions to capture costs and benefits. The User Benefits can be calculated by applying a value to time savings associated with faster, more reliable transit service, and reduces automobile expenses. Environmental benefits are calculated based on avoided regional vehicle emissions less the emissions directly related to the project. Environmental costs are associated with the compensation required for mitigation.

Multiple Account Evaluation allows agencies to more fully understand and assess the impacts of proposed projects or initiatives. The primary purpose is to inform, not resolve, public policy debates by providing more transparent, comprehensive and consistent valuation of costs and benefits.

life cycle assessment

Life Cycle Analysis (LCA) aims to capture direct and indirect environmental impacts from the time raw materials are extracted until final disposal. Intended and unintended environmental consequences of materials and processes are included. LCA enables agencies to more fully understand their environmental footprint and is vital in accurately determining sustainability performance.

Agencies should consider life cycle impacts of projects and maintenance activities, including material selection, design, construction and operating practices, and disposal procedures. Through use of LCA agencies learn about environmental impacts and can weigh them to best suit project and operational needs. Numerous consulting services and on-line tools guide users through the LCA process. The U.S. government incorporates LCA into its procurements using Building for Environmental and Economic Sustainability (BEES). BEES is a tool that uses the LCA approach specified in the ISO 14040 series of standards and is supported in part by the U.S. EPA Environmentally Preferred Purchasing Program.

Integrating LCA into procedures at agencies will enable use of materials, designs, and practices that support high quality transit

service with the lowest adverse environmental impacts. For more information on LCA, see U.S. EPA's website at www.epa.gov/nrmrl/lcaccess/. For more information on BEES, see www.bfrl.nist.gov/oae/software/bees/bees.html

environmental management system

An Environmental Management System (EMS) is a tool to help an organization understand and systematically improve its environmental impacts. Proactively addressing environmental impacts allows an agency to find the most cost effective ways to improve environmental sustainability. Comprehensively addressing environmental impacts can also lead to improved conditions for employees, strengthened relationships with the community, and increased ridership. As an organization becomes comfortable with an EMS and begins to move toward more holistic sustainability goals, the EMS can be expanded to explicitly include social and economic principles, effectively becoming a Sustainability Management System.

An effective EMS guides exploration of environmental opportunities that are compatible with the individual agency through the 'Plan, Do, Check, Act' cycle (The Shewhart Cycle).

- ***Plan:*** 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 employee responsibilities in meeting these goals.
- ***Do:*** Delegate responsibilities, set-up and conduct employee training, and communicate EMS goals and procedures with employees.
- ***Check:*** 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.

- ***Act:*** Evaluate the system in terms of effectiveness and appropriateness for reaching company goals. Identify new goals and make adjustments to the EMS.

For detailed guidance on implementing an EMS, see www.epa.gov/EMS/. External partnering and collaborative goals, internal awareness, and performance measurement are all key elements of a successful EMS.

measurement

Agencies will only know if transit is becoming more or less sustainable if performance is measured. Through performance measurement, agencies will be aware of actual results. Agencies should work with stakeholders to find mutually beneficial goals and tie measurement proxies directly to these goals. Agencies should also 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, implementation, operations, maintenance, marketing, and public affairs stakeholders to align interests, goals, opportunities, protocols, and reporting processes.[6]

Key components of measurement which should be incorporated into recommended practices include:

- ***Outcome or Goals:*** What you are ultimately trying to accomplish (i.e. improved air quality, greater accessibility)
- ***Outputs or Strategies:*** Steps to reach outcomes (i.e. renewable energy purchases, stakeholder meetings)
- ***Indicator:*** Proxy used to measure delivery of outputs and achievement of outcomes (i.e. percent of energy from renewable sources, number of stakeholder meetings).

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6 Submittals may include: Copies of meeting minutes, signed 'internal' agreements between Agency representatives, and copies of commissioning reports to relevant Agency representatives.

- ***Target:*** Specific, tangible goals (i.e. 10% of energy from renewable resources by a specific date).

Means of measuring performance must be evaluated to determine that they are really tracking overall sustainability. Various social, economic, and environmental consequences, both intended and unintended, must be considered and understood. For example, an increase in emissions may be positive or negative for overall sustainability because increased emissions can result from (1) increasing the transit fleet to accommodate increased ridership or (2) increases in bus idling. Carefully considering what increases and decreases in emission levels represent may lead agencies to measure emissions, for example, by ton per passenger mile traveled.

Accurately measuring emissions from transit systems may also requires inclusion of emission offsets from other modes of travel. Improved public transportation will reduce the number of private passenger vehicles used on a daily basis. The potential emissions of vehicle trips avoided through transit use should be subtracted from the direct emissions of transit operations for a more accurate net measure. For guidance, review the practices of AC Transit in Oakland, CA at: www2.actransit.org/environment/reducing_emissions.wu

This document recommends measurements solely for the included guidelines. Creating measurements for both the overall sustainability of a transit system and sustainability of specific projects is also highly recommended. Numerous reports and guidelines provide best practices for measuring sustainability in transportation and offer specific recommendations for transit, such as the International Association of Public Transport's (UITP) Sustainable Development guidelines (www.uitp.eu/Public-Transport/sustainabledevelopment/) and the Global Reporting Initiative (www.globalreporting.org).

Sustainability Indicators are being developed for the Canadian Urban Transit Association (CUTA), in partnership with TransLink, the South Coast British Columbia Transportation Authority, to assist agencies in developing measures to track and report on progress toward sustainability goals. Project specific indicators are also being developed by TransLink, in partnership with the federal and provincial governments.