RATP Dev USA

Sustainable Transportation

A White Paper by RATP Dev USA featuring Proterra, Inc.

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Solving for sustainable transportation is – dare we say it – one of the world's largest problems. It's true. Although public transit moves large amounts of people using minimal resources, vehicles are still releasing emissions along the way. We are contributing alongside individual car owners, ride-sharing companies, and transit agencies across the globe. If we look ahead to the future, it is clear change is needed. But where do you start? How do you make the switch, and what do you switch to? What's required to make such a change - are you and your extended teams prepared? From start to finish, this White Paper will take you from the importance of sustainability and challenges in the transit ecosystem to modern-day and evolving solutions, including the tools, resources, and strategies to utilize them.

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1 Importance of Sustainability

Sustainability is a broad concept that can be defined in many ways. One of the most widely accepted describes it as something that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Global Concerns

Addressing the problems created by human development and activity is imperative as pollution, waste, carbon emissions, and traffic all pose major threats to human health and the environment.

Air Pollution: According to the World Health Organization (WHO), 9 out of 10 people live in places where air quality exceeds WHO guideline limits. The organization estimates that 4.2 million fatalities occur every year from exposure to outdoor air pollution.[1]

Congestion: Each year, nearly 1.25 million people die in traffic accidents, and another 20-50 million are injured or disabled.[2]

Hazardous Waste: Industrial facilities around the world release 310 Kg of toxic materials into the environment every second.[3]

Carbon Emissions: Based on 2017 U.S. EPA statistics, transportation produces 28.9% of all global greenhouse gas emissions making it the largest producer of CO2 emissions than any other industry.[4]

Climate Change: NASA reports that the Earth's surface temperature has risen approximately 1.62 degrees Fahrenheit since the late 19th century and that the ocean temperature has risen 0.4 degrees Fahrenheit since 1969, largely due to carbon dioxide and other emissions.[5]

Transit Industry & Sustainability

When applied to transportation, sustainability is about balancing current mobility needs with future ones. Public transit, by definition, is a sustainable practice because it moves more people using fewer vehicles and resources. Taking sustainability a step further, there are practices and procedures transit agencies can adopt to be increasingly environmentally friendly.

According to the American Public Transportation Association (APTA), sustainability in the public transportation industry includes:

1. Employing practices in design and capital construction, such as using sustainable building materials, recycled materials, and solar and other renewable energy sources to make facilities as "green" as possible.
2. Employing practices in operations and maintenance, such as reducing hazardous waste, increasing fuel efficiency, creating more efficient lighting, and using energy-efficient propulsion systems.
3. Employing community-based strategies to encourage land use and transit-oriented development that increase public transit ridership. [6]

Importance

Sustainable transport involves short-term and long-term components to meet global concerns encompassing social, environmental, human health, and economic requirements.

Meaningful and carefully crafted sustainable transportation policies and procedures provide mobility opportunities while limiting potentially significant adverse effects on the environment. Communities that provide enhanced and interconnected travel choices while producing less waste and pollution results in improved human health, more livable cities, better land-use measures, and economic vibrancy.

According to the European Union Council of Ministers of Transport, a global perspective of sustainable transport:

- Meets access and development needs in a manner consistent with human and ecological health, promoting equity within and between successive generations.
- Is affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy.
- Limits emissions and waste by using renewable resources while minimizing the impact on the use of land and the generation of noise. [7]

In pursuit of truly sustainable transportation, transit agencies can face various challenges along the way. To overcome these obstacles, agencies must be prepared and open for change, constantly seeking all forms of viable solutions that promote Sustainability in Transportation. Currently, an overarching goal is to socialize challenges and their evolving solutions, as well as best practices that can we can implement to impact our environment positively, as we head into the future – towards smarter cities.

2 A Shared Responsibility – Challenges in the Environment

Sustainability is a responsibility we all share. To create viable, long-term solutions, it is important to understand the associated challenges and obstacles. There are four major contributing factors negatively impacting sustainability in the environment. These include:

1. Human Behavior and Population Growth
2. Costs Associated with Upgrading a Fleet
3. Development of an Adaptable Infrastructure
4. Comprehensive Maintenance

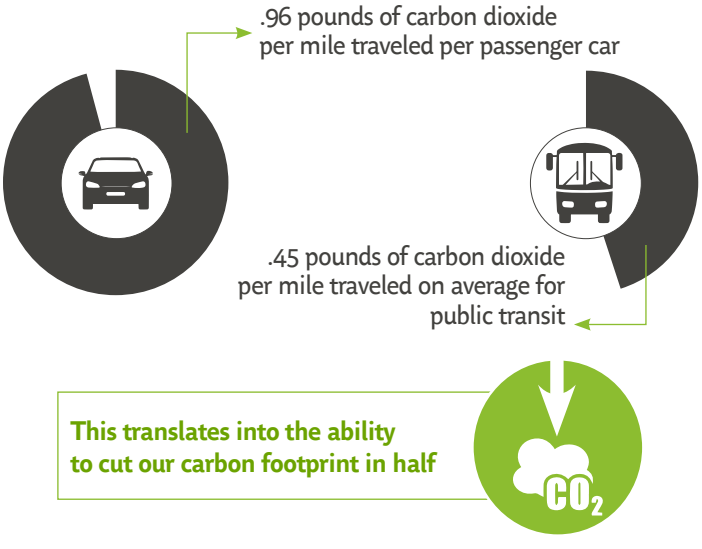
The ambiguity that surrounds these factors is unique for each community. As such, questions need to be identified, understood, and answered appropriately. For instance, does the local jurisdiction's plan for an adaptable infrastructure take into account integrating new technologies, and how to work with their limitations?

By taking a closer look at each of these contributing factors, we can uncover the possible solutions towards a more sustainable future.

Human Behavior and Population Growth

According to the United States Department of Transportation's Federal Highway Administration, Americans now drive an average of 13,476 miles per year - the most in history. Owning a car represents independence, convenience, and freedom. Individuals rarely reflect on the environmental impacts owning a car can have. For example, a vehicle's emissions are one of the biggest contributing factors to global warming and other detriments to our environment. As our population continues to grow it is estimated that by 2030, passenger traffic will increase by 50%; globally, the number of vehicles on the road is expected to double by 2050.[8] This growth rate far exceeds the sustainable practices currently being utilized by our society.

Alternate options, including public transit, can improve these negative impacts on our environment by reducing traffic congestion and lowering the levels of CO_2 emissions released into the air. Consider the CO_2 emissions per passenger mile for individual cars versus transit:[9]



Public transportation is becoming more predictable, as a result of technological advancements, it is increasingly more convenient, and continues to be a more acceptable mode of transportation. Furthermore, the increase of hybrid and electric buses in transit solidifies this option as a viable, sustainable solution.

Costs Associated with Upgrading a Fleet

Public transit has historically been comprised of diesel fuel bus fleets; however, a growing number of hybrid, electric, and autonomous vehicles are being ushered into the industry as sustainable alternatives are in higher demand. As these vehicles become increasingly available, consideration shifts to the funding of upgrading the current fleet. Transportation funding comes from multiple sources, including federal, state, and local levels. Federal funding is supplied by the Department of Transportation's Federal Transit Administration (FTA).

In March of 2019, the U.S. Department of Transportation announced an $85 million funding opportunity for Technologically Advanced Transit Buses where eligible applicants could apply for competitive grant funds through this Low or No Emission (Low-No) Bus Program. [10]

Transit networks in communities at the forefront of moving towards a sustainable future are proactively taking advantage of these funds to assist in the upgrade to newer, hybrid and electric buses.

Consider the financial investment required to upgrade a fleet:

- The average cost for an electric bus is around $700,000, compared to about $445,000 for diesel
- Take a transit system with 100 buses making the transition to electric buses
- $700,000 – $445,000 = $255,000 difference x 100 vehicles = $25,500,000 investment above the cost to replace current buses with diesel [11]

Consequently, interested cities are choosing to upgrade to electric buses incrementally, making it a part of their 2040 Transit Plans. Looking at the design of a Battery Electric Bus, the number of moving parts is significantly lower. The brakes are a good example; the regenerative braking system, inherent in electric vehicles, reduces the wear of the brake pads by turning the kinetic energy of the vehicle into electricity that is returned to the battery packs. When taking a holistic approach to spending money to upgrade a fleet, the prices suddenly start to look very similar.

Over the long-term, the costs of purchasing a Battery Electric Bus can be offset when considering the overall maintenance savings over the life of the bus. Roughly, $237,000 is saved over the lifetime of the bus when compared to diesel-hybrid buses. While upgrading a fleet is expensive, the benefits are far-reaching and positively affect not only the environment but the community as well.

Did you know?
It is about 2.5 times cheaper to power vehicles with electricity compared to diesel fuel making this sustainable solution significantly more beneficial on a long-term basis.

Transit systems can take advantage of grant programs at the state and local levels, which vary from location to location, but also serve as a means to financially support the transition of diesel buses to more sustainable fuel sources. As attention continues to increase around the importance of protecting the environment, the need to implement sustainable best practices in the transit industry will become a mandate as opposed to an option.

Adaptable Infrastructure

An electric bus fleet and autonomous vehicles require a different infrastructure to operate than the traditional diesel buses that have been the staple for public transit. Electric charging stations are required at the bus facility (depot charging) and potentially along routes (en route charging), considering battery-powered buses can run around 100-150 miles (conservatively) on a single charge. Therefore, building an electrical charging strategy is critical to the success of implementing an efficient fleet. Throughout the process of converting a transit system to a more sustainable fleet, special attention must be given to factors such as vehicle battery capacity, discharging rate, charging dock locations, charging speed and the cost of electricity.

Electric vehicles are powered by many battery cells, necessitating an effective battery management system (BMS). Real-time management of the battery discharge rate is necessary to extend the life of batteries in powering the electric vehicle, based on physical dynamics and operational history; encompassing environmental factors, driver behavior, vehicle programming, and traffic.

Main Transformer to convert power into 480V (in dedicated and secure room)

Charging Points ensuring the conversion from AC to DC and the bus recharging (5 to 8 hours during the night)
Depot Charging current technologies offer up to 125KW charging capabilities

Circuit Breaker to avoid that a punctual incident affects the entire facility

Overhead/on-route charging operates at different voltages based on which charger is hooked up to it.

Adaptable infrastructure will become less of a challenge as technology continues to advance, providing increased efficiencies such as greater energy density and longer battery life. Companies such as Proterra are continually making improvements to the electric buses that they manufacture for increasingly efficient user experience. The future is electric.

Comprehensive Maintenance

RATP Dev sat down with Proterra's Manager of Training, James Hall, to discuss best practices regarding Comprehensive Maintenance for Electric Buses.

Best Training Practices with Proterra

1. **Start with Similarities**
    a. While the technology seems completely new from an outside perspective, most components and subsystems are similar, or even the same, as what is currently industry-standard.
        i. For example, suspension, ADA accommodations, and braking are all examples of systems that, generally speaking, are the same.
2. **Emphasize Safety**
    a. Electricity, when used in systems such as electric vehicles is invisible. Manufacturers spend ample time designing multiple levels of safety into the vehicle subsystems.
        i. Always remember this should never be considered a substitute for best safe practices.
3. **Promote Confidence in Skills**
    a. Every person, from operators to schedulers and technicians to managers, have the skills to integrate Battery Electric Buses into their fleet successfully.
        i. Training is an on-going process, and individuals should feel empowered to find the answers to any questions they may have.
4. **Stress Behavioral Changes Toward Efficiency**
    a. Electric vehicles produce the best range when operated efficiently.
        i. This includes setting the cabin temperature to an efficient setting for the climate, accelerating smoothly, planning out stops to regenerate as much energy as possible, and maintaining the vehicle to promote very little rolling resistance.
5. **Accentuate the Improvements**
    a. Audiences want to know how this new technology will benefit and improve their lives.
        i. Riders are often an overlooked audience when training. The people that are being transported should also be made aware of what to expect with new vehicles.
6. **Engage a Wider Audience**
    a. Traditional "silos" of information tend to limit "who learns what." However, with Battery Electric Buses, it is often beneficial to discuss the basics of something like how the charger works with someone such as an operator.
        i. In doing so, communication regarding what is happening if/when a fault is encountered is significantly improved, thus reducing the possibility of a vehicle being taken out of service.

Operation and Maintenance

For successful implementation of an electric fleet and subsequent ongoing maintenance, it is crucial that all training for Operations and Maintenance employees is updated to reflect changes in timetables, restrictions, and the overall impact on maintenance. Additionally, any operational data generated by electric buses need to be carefully tracked and analyzed. In doing so, the performance and consumption rates of different vehicles need to be benchmarked, and in parallel, strong coordination must be maintained with the

bus manufacturers to remediate any technical issues that may arise.

Transition and Conversion

When converting your fleet, authorities must ensure that there is minimal impact on passengers and residents. Based on the community's unique needs, a suitable plan must be developed for depot conversion and progressive investment.

Did you know?
RATP Dev's approach involves assessing the transition timeline and breaking it out into structured phases to ensure pitfalls are avoided at all stages.

RATP Dev's Green Fleet Service Approach

Energy Strategy	Transition	Operation & Maintenance
Prepare your Bus Fleet for Energy Conservation	Successfully Convert your Bus Fleet	Benefit from Optimum Quality Service

Key Players

Regulators	Suppliers	Maintenance
Federal Transit Administration (FTA), U.S. Department of Transportation (USDOT)	Proterra Inc., BYD Motors Inc., NFI Group Inc., GreenPower Motor Company Inc., Gillig LLC, Blue Bird Corporation, Nova Bus Corporation, and The Lion Electric Co.	Consulting and engineering firms (SETEC, EGIS, etc.), Transit agency contractors

The U.S. electric bus market is projected to reach $1,554.5 million by 2024[12]

Conclusion

Each challenge comes with a solution. The Intergovernmental Panel on Climate Change concluded that greenhouse gas emissions must be reduced by 50% to 85% by 2050 to limit global warming and avoid many of the catastrophic impacts of climate change.[13] In the transit industry, it is our shared responsibility to continuously improve upon sustainable solutions and best practices to lower our carbon footprint and contribute to the health and longevity of our environment.

3 The Green Protocol – Evolving Sustainable Solutions

In today's world, sustainable practices and concepts are no longer being viewed as experiments, but rather, have become a necessity in the transit ecosystem; a requisite to build smarter cities. By adapting to the economic and social needs of our time, sustainable practices are growing and evolving in line with the latest technologies.

Did you know?
Our vehicles are 90 percent cleaner than they were in the 1960s[14]

Smarter Cities

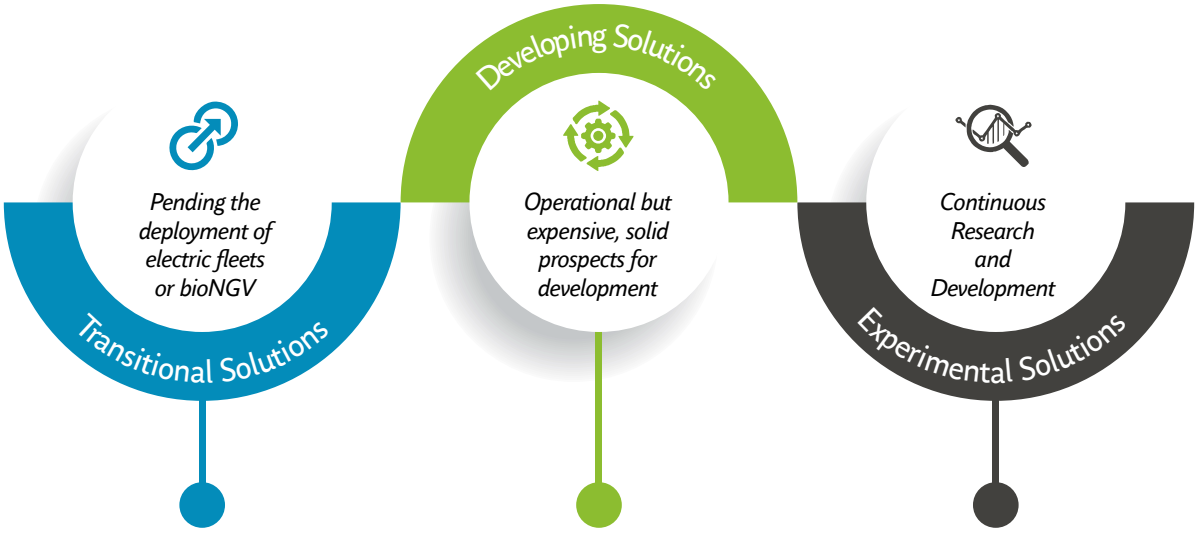
For smart mobility to occur, it is necessary to develop seamless multimodal access. Introducing clean mobility options along with the development of integrated technologies, help promote efficiency, and raise the quality of life in a community.

Fuel Distribution

When seeking cleaner fuel technologies, one can always look at the public transportation sector for the latest fuel innovations. New solutions are constantly being developed to drive forward truly sustainable transportation.

Did you know?
Of all the bus fleets in the United States, 21.7% use compressed natural gas or CNG [15]

Current Solutions



Alternative liquid fuels/biofuels such as Hydrotreated Vegetable Oils, ethanol, etc.

Synthetic fuels - made from biomass (BTL), natural gas (GTL) or coal (CTL).

NGV: methane-like natural gas

BioNGV: gas extracted from organic waste

The hydrogen engine: this technology is based on storing energy as liquid hydrogen to recharge a battery (the "fuel cell") that powers an electric motor.

When compared to diesel, these technologies have varying environmental impacts, levels of maturity, costs, and operational impacts:

	Fuel Alternatives	Hybrids	BioNGV	Electric	Hydrogen
Environmental Benefits*	■■□□□□□	■■□□□□□	■■■■□□□	■■■■■■■	■■■■■■■
Maturity	■■■■■■□	■■■■■■■	■■■■■■■	■■■□□□□	■□□□□□□
Extra Cost	■■■□□□□	■■■■□□□	■■□□□□□	■■■■■■□	■■■■■■■
Operational Impact	■■■□□□□	■■□□□□□	■■■■□□□	■■■■■■□	■■■■■■■

** vs Diesel*

The Future is Now – Electric & Autonomous Vehicles

Electric Vehicles – Zero Emissions

Did you know?
There are approximately 300 electric vehicles currently active and in motion throughout the U.S.

According to Reuters, the demand for additional electric vehicles is steadily growing due to the positive impacts it has on the environment, including zero emissions. A long-term approach, considering upgrades to the electrical grid and the heavy financial investment, is necessary to convert a transit network from diesel to an electric fleet. To ensure efficient and smooth operations, transit agencies need to develop a holistic plan for conversions. This robust transition and the subsequent maintenance can be in done in-house or outsourced to a transit contractor.

Autonomous Vehicles: Reducing Congestion

Studies find that the savings from the driving efficiencies associated with self-driving vehicles result in a reduction of energy use and associated greenhouse gas emissions of up to nine percent compared to conventional.

California and Nevada have passed legislation allowing for driverless cars to operate on public roadways, and other jurisdictions are following suit.[16]

Drivers of Change

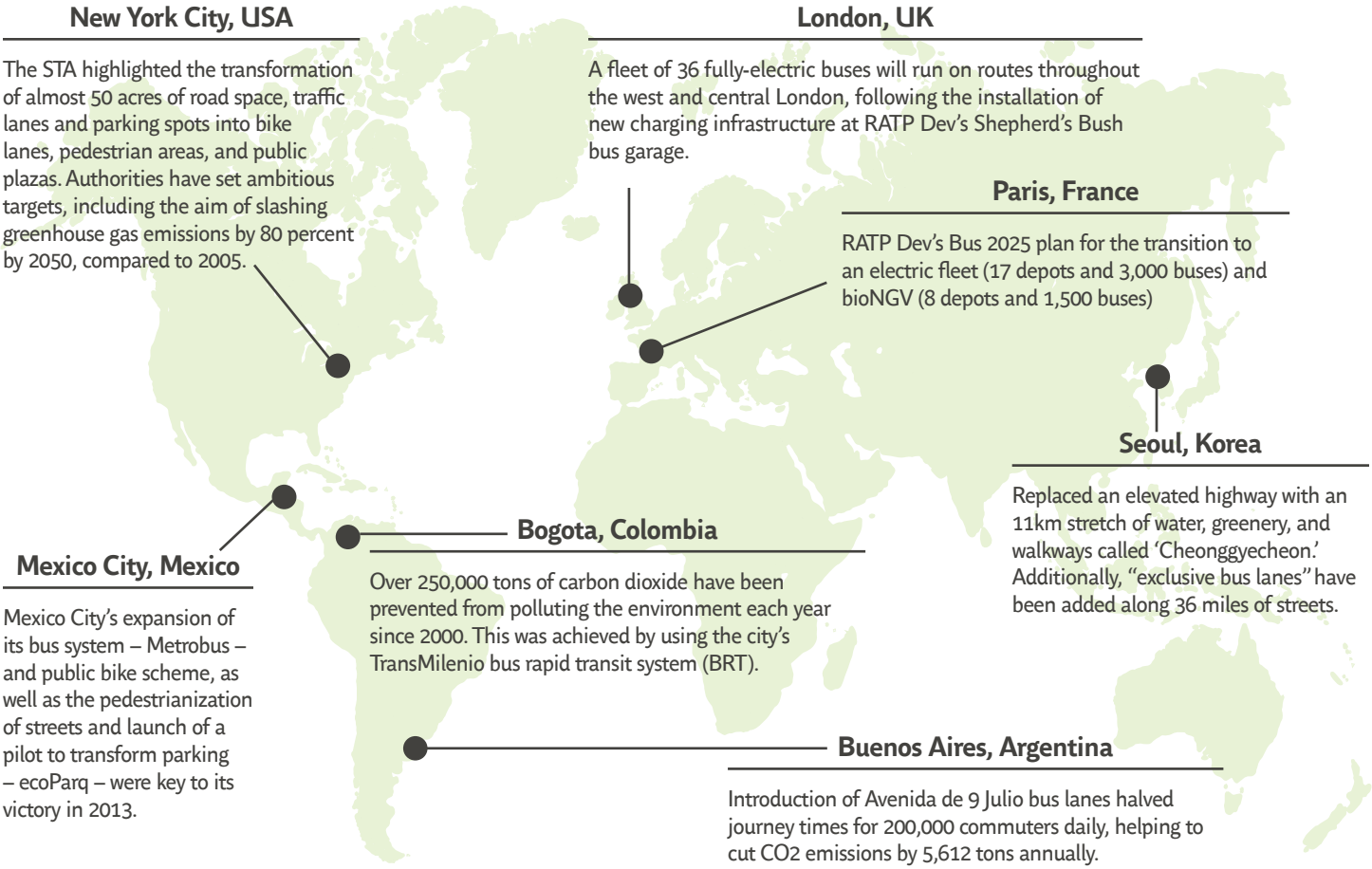
1. Climate Change Awareness
2. Government Regulation
3. Technology
4. Infrastructure

Sustainability Around the World

Our experience with alternative fuel system draws on innovation to improve our environmental performance by introducing and offering greener mobility solutions across the world.

Reducing noise, disturbance, and pollution – our parent company, RATP Group, is acting today for the city of tomorrow, by committing to Bus 2025, a plan aimed at making the Paris region's fleet of 4,600 buses 100% clean – i.e., 80% electric fleet and 20% biogas – by 2025.

Take a look at other ways cities are 'going green' by making sure their transport links are efficient, sustainable, and easily accessible.



Think Local, Leverage Global

In the US, RATP Dev is a pioneer in the implementation of Compressed Natural Gas (CNG) as an alternative fuel in public transportation. In partnership with several agencies, many partial or full vehicle fleets have been converted to CNG fueling. In addition to CNG, we operate a few of the largest electric fleets in the world! Here are a few:

1. **Trinity Metro (Fort Worth, TX)** – CNG fleet including 177 transit buses, accumulating over 100,000,000 miles on CNG fuel
2. **DC Circulator (Washington, DC)** – a fleet of 14 battery-electric vehicles on six Fixed-Routes including the National Mall loop which takes passengers to more than 25 museums, monuments, and memorials in Washington, D.C
3. **Zion National Park (Zion, Utah)** – one 40-foot and two 35' long-range Proterra Electric Buses
4. **ART (Asheville, NC)** – five 35' long-range Proterra buses are in-service
5. **Sun Tran (Tucson, AZ)** – Tucson's first zero-emission battery electric bus hit the streets in Fall 2018!
6. **Citibus (Lubbock, TX)** – Two Proterra buses

TRINITY METRO circulator NATIONAL PARK SERVICE ART Asheville Redefines Transit citibus sun tran

4 The 'Green Way' – Transit Best Practices

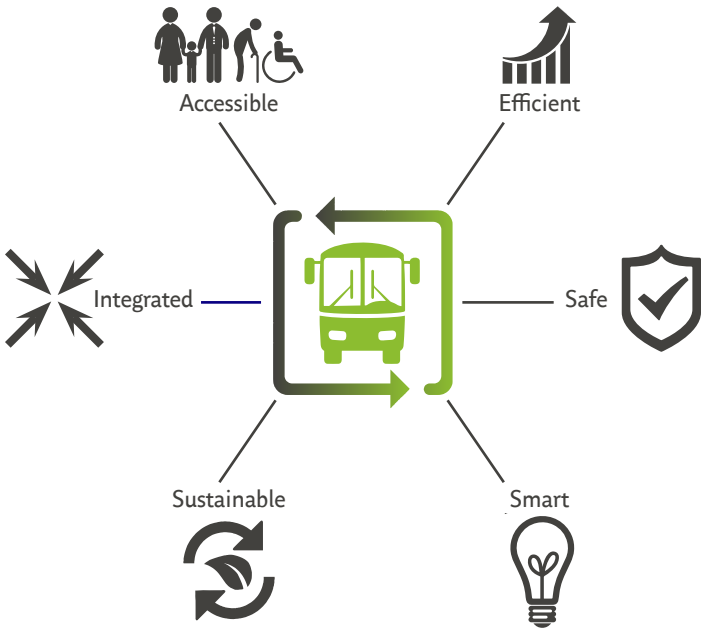
Enhancing Quality of Life

Public transportation is a major factor to protecting the natural environment. By transporting large numbers of people with fewer vehicles, it reduces air pollution and improves air quality, minimizes consumption of fossil fuels, and results in more efficient neighborhood designs and land-use policies. Ultimately safe, attractive, convenient mass transit is key to helping individuals live full and productive lives.

Utilizing transit planning enhances the quality of life by creating better mobility access and options into the future. This translates to efficient public transportation that creates livable, hospitable, and equitable communities.

To make mass transit a viable option for riders and encourage sustainability, agencies must provide enjoyable and safe transit services. Vehicles should:

- Be well-maintained – clean and free of debris and unpleasant odors.
- Produce minimal noise and vibrations (with installed audible warning systems), so passengers get a smooth, comfortable and safe ride.
- Have enough lighting, large windows, well-designed seating, adequate circulation space for passengers, and good climate control.
- Provide accurate and easy-to-use rider information, such as mobile apps, maps, and public address systems.
- Provide amenities to improve the riding experience, such as wireless technology and mobile payment systems.[17]

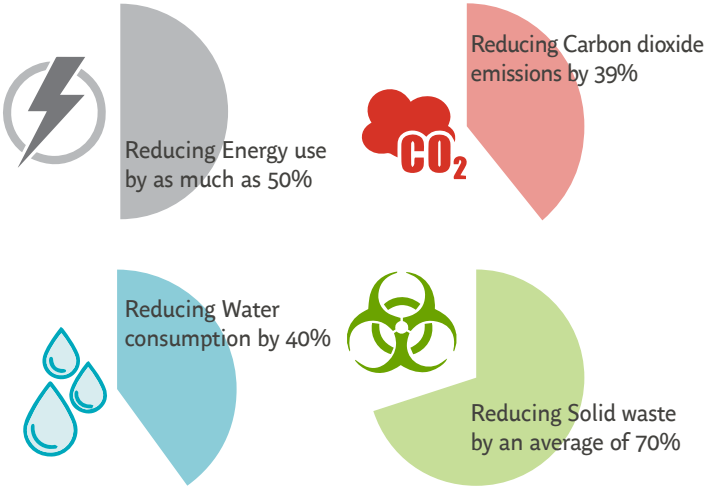


Public Transportation – The 'Green Way'

Moving forward with sustainable transportation, the industry must take into consideration how resources are used and discarded. At each step in the process -- from the construction of transit facilities and the disposal of waste to the actual materials and chemicals used for operations and maintenance -- agencies must choose how they want to "go green."

Sustainable Materials: Green buildings make efficient and effective use of resources – energy, water, raw materials, and land – and provide a healthy work environment. By applying green building practices to new construction and refurbishing existing facilities, transit agencies can conserve resources through lower construction, operations, and maintenance procedures.[18]

Data suggests employing green building practices can lower the costs of construction, operation, maintenance, and utilities while reducing:



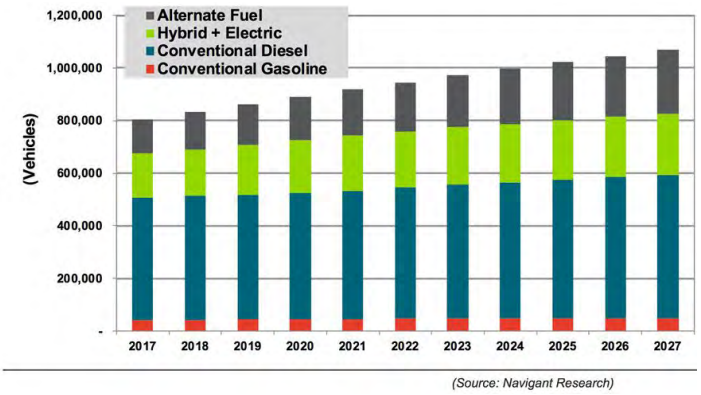
Energy Conservation: Energy efficiency can be achieved by using lighter-weight vehicles and switching to cleaner propulsion systems. Routes can also be designed to minimize energy consumption.

Emissions & Pollution Control: Transit agencies can adopt a green mindset by developing policies and practices aimed at reducing wastewater and stormwater, fuel discharges, hazardous waste, trash, and CO2 emissions. The process involves the proper storage, use, and disposal of hazardous materials. Likewise, sustainability requires that, whenever possible, metals, wood, paper, batteries, waste oil, solvents, grease, oil filters, antifreeze, tires, and electronic equipment should be recycled or reused.

Moving Away from Diesel Fuel: Fuel sources for bus fleets are evolving dramatically and quickly. According to the APTA, in 1995, more than 95% of buses were diesel-powered. By 2017 that number had dropped to just under 42%. Meanwhile, cost-effective and environmentally sound fuel sources are on the rise:

- Hybrid electric buses increased from 1% in 2005 to 21% in 2018
- Buses powered by natural gas increased from 18.5% in 2008 to 28.5% in 2018 [19]

As transit agencies continue to try to reduce emissions, it appears that the market for non-diesel buses will continue to grow.



(https://www.vox.com/energy-and-environment/2017/10/24/16519364/electric-buses)

Community Based Programs and Strategies: While many issues related to sustainability are global and can be managed with universal solutions, communities often have specific sustainability issues and concerns that are unique to them and must be addressed directly. To identify those issues, transit professionals should seek out community-based programs. Local groups are often already aware of the issues that are important to that community, and can identify key local leaders and provide background and guidance.

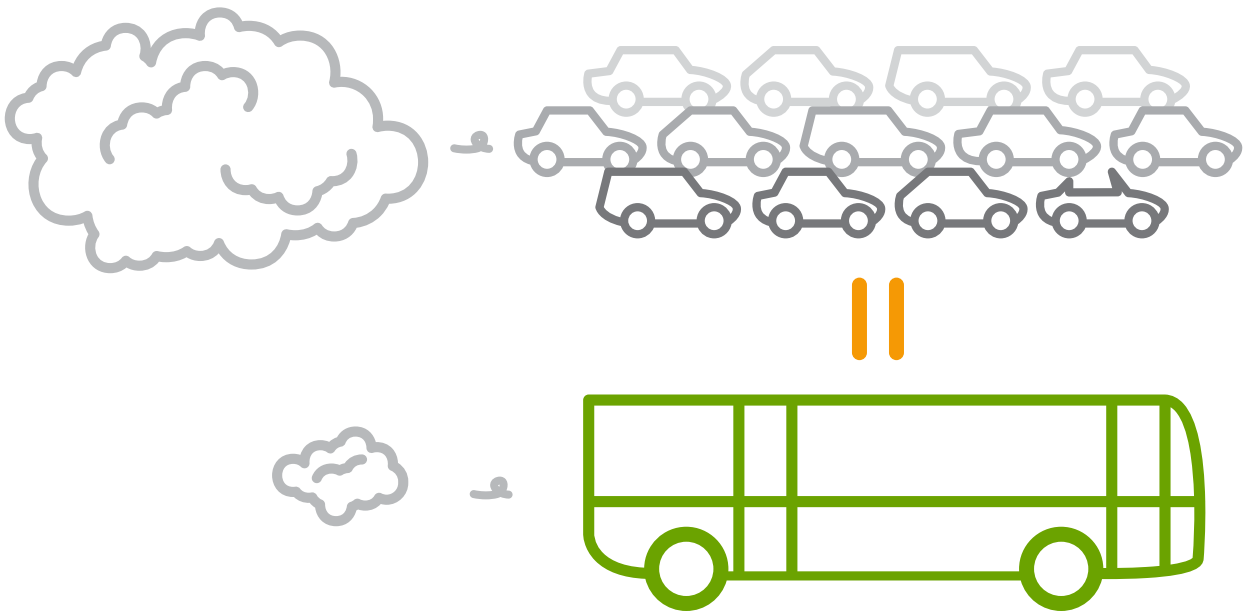
5 The Way Forward – Long Term Benefits

The public transit industry must continue to proactively implement sustainable strategies to ensure that we can provide mobility to our existing communities without impairing the mobility of future generations or the health of the planet. Good business practices that make environmental sense are valuable to the industry and beneficial to the community at large.

Long-term goals of Sustainable Transportation (U.S. DOT) include:

- Improve mobility by providing enjoyable transit services
- Reduce per-capita automobile vehicle miles traveled
- Reduce passenger transportation-generated CO2 and other greenhouse gases
- Create livable communities by facilitating eco-friendly mobility such as walking, biking, and public transit
- Reduce stress, loss of productivity, and traffic casualties and related health care costs caused by automobile travel

On your way to achieving U.S. DOT's long-term sustainability goals, start small and "go green" by adopting the transit industry's best practices for sustainable transportation. By getting involved with local activism, you can spread the "green word" and continue to impart change. Next, follow the green protocol, by leveraging new technologies to transform transportation in your community. Through a heightened awareness of current challenges and evolving solutions, you too can play a role in protecting the planet's ecosystem, while creating seamless mobility options that improve our quality of life.



About the Authors

RATP DEV USA

Founded in 2002, RATP Dev operates and maintains urban transportation systems in 12 countries on four continents (United Kingdom, France, Italy, Switzerland, Algeria, Morocco, South Africa, Saudi Arabia, Qatar, India, China, South Korea, the Philippines, and the United States of America). With more than 1.5 billion passengers travelling on its networks every year, RATP Dev demonstrates every day its extensive and renowned expertise in a wide range of mobility services, ranging from rail, regional express rail, tramway, to bus, cable car and sightseeing activities. RATP Dev leverages in France, outside of Paris, and across international markets the technical expertise and experience of RATP Group, the leader in driverless and tramway operations and operator of the Paris network, one of the largest public transportation networks in the world. In North America RATP Dev employs over 6,000 team members transporting more than 78 million passengers in over 30 locations across the US, operating a wide range of services.

PROTERRA

Proterra is a leader in the design and manufacture of zero-emission electric transit vehicles and EV technology solutions for commercial applications. Proterra provides a suite of products, services and financing options for a seamless transition to clean, quiet, battery-electric fleets. Designed for durability, safety and energy efficiency and validated by rigorous U.S. independent testing, Proterra products are proudly designed, engineered and manufactured in America, with offices in Silicon Valley, South Carolina, and Los Angeles. For more information, visit: http://www.proterra.com and follow us on Twitter @Proterra_Inc.

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RATP Dev USA

3800 Sandshell Drive | Suite 180
Fort Worth, Texas 76137
(844) - RATPDEV
www.ratpdevusa.com

Connect with RATP Dev USA

Twitter: @RATPDevUSA

LinkedIn: RATP Dev USA