Promoting Energy Efficiency in Urban Transportation

Technical, Infrastructure, and User Analysis

Clara SIMÕES COELHO, Anna-Lee CLARTE, Chloé TOUPET, Charles WILSON-JACKSON, Victoria THOMAIDES, Laura LUNGENSTRASS BUSTAMANTE

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Abstract

This report examines how cities can improve energy efficiency in the transport sector through the implementation of effective and transferable policy measures. As urban areas account for a growing share of global energy consumption and greenhouse gas emissions, improving transport efficiency has become a critical priority for both climate mitigation and energy security. The analysis is based on a review of scientific and policy literature combined with a case-study approach covering cities across diverse geographic and economic contexts. The report structures its findings around three key pillars: technological advancements, infrastructure development, and user-focused policies. The findings highlight that no single policy is sufficient to achieve significant efficiency gains. Instead, successful strategies rely on integrated approaches that combine clean technologies, well-designed infrastructure, and behavioural change. Cities that implement coordinated measures across these areas achieve more substantial and sustained impacts. By identifying concrete best practices and analysing their outcomes, this report provides actionable insights for policymakers and contributes to the development of scalable solutions for more energy-efficient and resilient urban transport systems.

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Table of Contents

1. Introduction

Half of the global population lives in cities, a share that will continue to grow as urbanisation accelerates (UN, 2025). As a result, cities account for approximately two-thirds of global energy consumption and are responsible for around 70% of global greenhouse gas (GHG) emissions (Vijayan et al., 2021). Within urban energy use, transport plays a particularly critical role due to rising mobility demand and increasing reliance on private vehicles. In parallel, transport represents a significant share of household expenditure, reflecting both the economic burden of mobility and the structural dependence on energy-intensive transport systems.

In cities, a large proportion of trips are short - often less than 30km - and can account for up to 50% of oil consumption by private vehicles (IAE, 2026). This highlights a key inefficiency in current urban mobility systems, where relatively short distances are frequently travelled using energy-intensive modes. Improving infrastructure and promoting public transport could reduce national oil consumption from cars by 1% to 3%, illustrating the scale of potential gains (IAE, 2026). Recent disruptions in global energy markets, including supply shocks linked to geopolitical tensions in the Middle East, have highlighted even more starkly the vulnerability of transport systems to oil price volatility. This reinforces the importance of long-term structural measures that can reduce dependence on fossil fuels and increase system resilience. Therefore, we find that urban transport policies aimed at improving energy efficiency offer a "win-win" opportunity with many co-benefits. By reducing energy consumption, they can simultaneously lower emissions, improve air quality, reduce household transport costs, and enhance public health outcomes.

1.1 Organization of the report

This report is structured around three key pillars: technological advancements, infrastructure development, and user-focused policies. Within each, we examine key policies and best practices aimed at improving energy efficiency in transport in the urban sector, with a focus on scalable and transferable solutions (see Figure 1). The case-study cities have been selected as best practices of energy efficiency strategies in Rwanda, United States, Indonesia, Brazil, Sweden and France (see Figure 2).

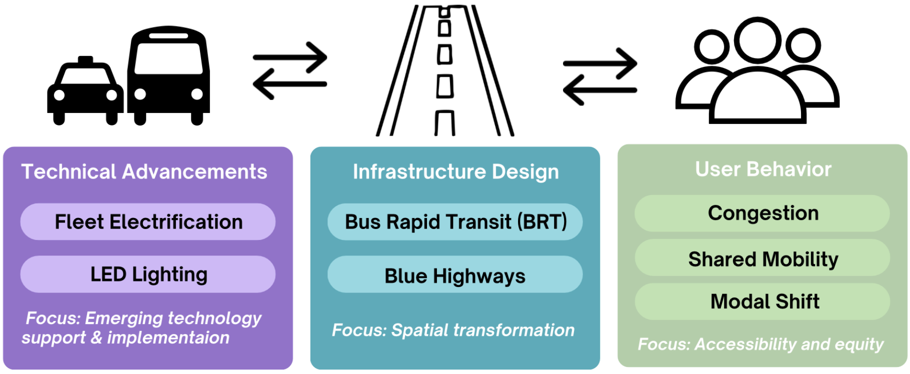

Figure 1: *Our three key pillars and respective policies.*

Figure 2: *Geographical coverage of our case studies.*

2. Methodology

The report's goal is two-fold: to provide policymakers across the globe with both inspiration for new transport related energy efficiency policies, and concrete best practices to guide policy design and implementation. Our first step was to identify key themes in the scientific literature, while ensuring comprehensive geographic coverage. Having acquired this background knowledge, we seeked expert practitioner knowledge to ensure the relevance of our findings to policymakers working on related issues. Our team reached out to over eighty individual practitioners across local government, local nonprofits and city coalitions, of which 5 were interviewed. We focused on technical advancements, infrastructure and users' behaviour to emphasize the interconnectedness of the transport system (see Figure 3). For each category, we analysed several policy options, followed by one or several case studies selected from across continents.

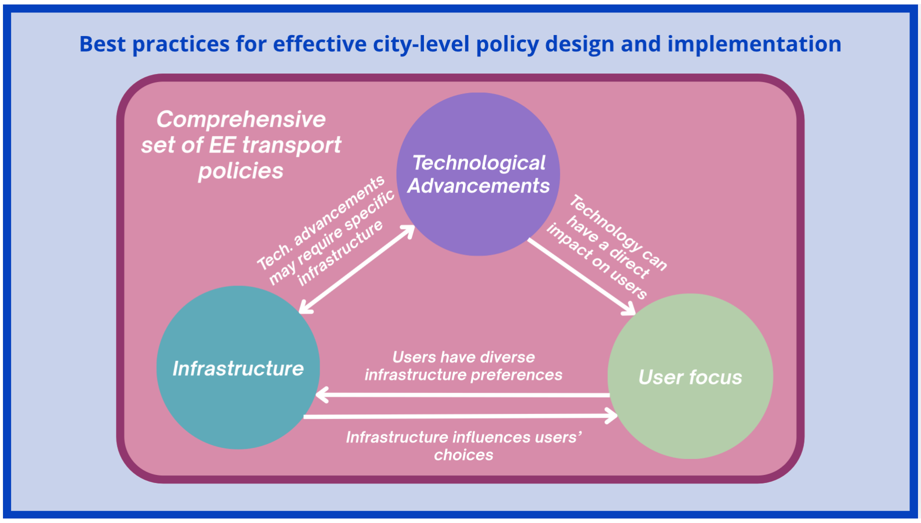

Figure 3: *Overview of our framework.*

For ease of reading, non-academic sources are cited in the annex and grouped by section to facilitate reference.

3. Policies Focusing on Technical Advancements

Technical advancement are essential for improving urban transport systems. By replacing technological components with more energy-efficient options, transport systems can enhance their energy efficiency and overall performance. To illustrate this, we will focus on two examples: fleet electrification and LED lighting.

3.1 Fleet Electrification

Fleet electrification is a technological upgrade in public transport from combustion engine vehicles to electric vehicles (EVs). Its potential benefits include reducing transport GHG emissions, improving energy efficiency and security, enhancing service quality, and reducing air and noise pollution in urban areas (ITDP, 2025a).

Best practices

- Ensure coordination between complementary infrastructure, such as charging stations networks (see Annex 10), grid capacity and management upgrades, such as off-peak charging, and integrated urban planning (ITDP, 2025a);
- Combine financial incentives, such as public subsidies, tax exemptions, leasing models, and public procurement requirements, to open up the market for EV vehicles;
- Develop workers training programs for EV deployment and maintenance, generating new quality jobs in the process;
- Establish administrative measures to create an optimal environment for EVs, including emission standards enforcement, restricted zones for green transport, technical standards for battery and e-waste recycling, and international cooperation protocols to facilitate technology transfer.

Notable examples include:

- Santiago de Chile, Chile: Santiago operates the second-largest electric bus fleet outside China — 3,800 buses, representing 55% of its total fleet and an 1,800% increase in five years (Ministerio de Transporte, 2026). As a result, energy consumption and maintenance costs have gone down by around 75% with buses now being 5 to 7 times more energy-efficient than combustion engine vehicles (OECD, 2023; CIGRE, 2024).
- Shenzhen, China: The first city in the world to achieve a fully electrified public transport fleet, reducing GHG emissions by 48% (Wired, 2020).
- Bogotá, Colombia: Currently operating 1,486 EVs across its public transport network, with 9 recharging yards and 503 charging stations, while also promoting electrification in its BRT systems (Enel, 2026; ICCT, 2024).

Impact on people

Fleet electrification positively affects public transport quality, GHG emissions, and public health. In Santiago de Chile, the transition to electric buses has reduced microparticle pollution by 75%, transport-related GHG emissions by 3%, and noise pollution by 64% along major avenues, with measurable improvements in sleep quality, concentration, and cardiovascular health (Ministerio del Medioambiente, 2026; La Tercera, 2026; Emol, 2025). Electrification also improves user perception: in Hanoi, Vietnam, the introduction of EVs attracted new riders, with 28% of previous non-users now willing to use the system (Nguyen, Pajani, 2023).

Limitations

- Insufficient infrastructure (charging stations and grid capacity);
- High upfront costs — EVs purchase cost is approximately 1.5 times higher than combustion engine buses (Karsan, 2026);
- Lack of financial incentives for operators to transition.

3.1.1 Case study nº1: Rwanda – Developing infrastructure and incentives to promote electric mobility (see case study in Annex 1)

The national government is developing infrastructure and creating a regulatory framework to incentivize investments in electric mobility through fiscal measures (e.g. tax exemptions), non-fiscal measures (e.g. rent government land for free or preferential treatment for EVs), and administrative measures (e.g. standards). 6% of the fleet is electrified, compared to 0% in 2020, which saved up to 20 billion Rwanda francs ($13 million) on oil importation. Consultation and information (to users and industry sectors) were deployed.

3.1.2 Case study nº2: United States – Madison city electric bus fleet and overhead charging program (see case study in Annex 2)

In Madison, the public transport operator deployed overhead charging systems for its electric buses using the pantograph technology. The use of the overhead charging method allows buses to recharge in minutes at route endpoints and operate continuously without long depot charging downtime. These buses have been more reliable for users than usual electric buses, faltering with cold conditions, providing a solution to transport disruption in extreme weather situations.

3.2 Shifting public and traffic lighting to LED

Replacing older energy-intensive light bulbs with LED is a cost-efficient way to achieve considerable energy savings. Indeed, LED light bulbs last 10 times longer than incandescent light bulbs, and consume one seventh of the power (Sabapathy, Whittaker; 2011). For instance, Guarulhos, Brasil, reduced its energy consumption by almost 90% and its annual energy bills by 290,000$, with a payback period of under three years (Sabapathy, Whittaker; 2011).

Best practices

- Eliminate unnecessary light fixtures – light fixtures may have been installed in a time of cheap and abundant energy, leading to excessive lighting. Hartford, Massachusetts, for instance, found that of its 860 street lights, 207 could be removed, and 7 needed to be added;
- Determine which lightbulbs to replace first, as well as optimal time to do so based on their life cycle and ownership. If lights are not owned by the city, specific terms of contract with the utility provider will dictate the cost and possibility of switching. For Hartford, this meant that for the remaining 348 light fixtures, it was economically beneficial to replace the 300 that qualified for a favorable policy of the relevant utility company;
- Consider installing sensors on light poles that allow for brightness to be dimmed when low activity is detected, if relevant for specific areas and conditional on budget constraints. A prime example of this technology is the city of Jakarta, Indonesia, detailed below.

Impact on people

The main impacts are positive by freeing up public costs for other projects and decreasing light pollution, an important co-benefit for biodiversity, especially bats. However, if sensors malfunction, leading to dim brightness at inconvenient times, this can negatively impact perceptions of safety.

Limitations

- For smart systems, the costs of the energy, software and equipment needed to send, store, and analyze data, as well as system maintenance might increase energy consumption and costs compared to the original policy.

3.2.1 Case study nº3: Indonesia – Jakarta's switch to LED public lighting (see case study in Annex 3)

In 2016, Jakarta replaced 90,000 high sodium pressure lightbulbs with LED ones over seven months, which reduced power consumption by 78.43%, with a payback period of 2.66 years. Sensors were installed to allow for the dimming of light intensity up to 50% when low activity is detected. Furthermore, lights are connected to a broader smart system allowing controllers to better target malfunctions by seeing the status of each light.

4. Policies Focusing on Infrastructure

Urban planning policies are fundamental to sustainable transportation. By shaping the design and allocation of public space for transport systems, they carry significant implications for energy efficiency and environmental performance. In this context, two key examples of urban planning related to transport are examined: Bus Rapid Transit (BRT) systems and blue highways.

4.1 Bus Rapid Transit System

Bus Rapid Transit (BRT) systems are urban planning initiatives that consist of exclusive high-capacity bus corridors with no access to other vehicles. By optimising vehicle flow, BRTs reduce congestion and enhance public transport energy efficiency and cut GHG emissions; for instance, the Provo–Orem BRT in Utah, US, has reduced annual gasoline consumption by approximately 3.46 million litres and CO_2 emissions by 8,110 tonnes (Kim & Ewing, 2024).

Best practices

- Combine it with fleet electrification, traffic signal priority, multimodal integration, and strategic deployment in metro-underserved areas to maximise its environmental and efficiency potential within urban public transport systems;
- Design BRT systems with inclusive approaches, such as gender perspective and reduced mobility considerations to widen access to economic opportunities and promote the integration of minority groups into the job market.

Notable examples include:

- Mexico City, Mexico: A BRT line focused on multimodal connectivity, integrating cycling and walking infrastructure into its design (Wilson, 2024);
- Transmilenio BRT, Bogotá, Colombia: The introduction of electric buses reduced the system's pollution contribution from 11.6% in 2018 to 3.1% in 2022 (Gobierno de Bogotá, 2026).

Impact on people

BRT systems can reduce commuting times by up to 50% by increasing traffic speed along dedicated corridors (Volvo, 2025). They also improve road safety, for instance, Transmilenio in Bogotá reduced traffic accidents by 94% (EBRD, 2021). When complemented by fleet electrification, BRTs can cut passenger emissions by up to 90% and significantly improve air quality, noise levels, and vibration in urban areas (Volvo, 2025). Moreover, BRT systems enhance access to services and economic opportunities: in Peru, BRT implementation increased female ridership by 10% and raised the likelihood of employment for women living near these systems (IDB, 2018).

Limitations

- Lower passenger capacity compared to metro systems;
- Dependency on complementary policies — such as electrification and modal shift — to maximize impact.

4.1.1 Case study nº4: Brazil – Salvador's BRT System Expansion (see case study in Annex 4)

Salvador's 12 km, 2-line BRT connects 9 underserved areas outside the metro network, benefiting approximately 340,000 daily users through reduced commuting times, improved safety, and less traffic congestion. By integrating electric buses, bike lanes, inclusive design, and gender-responsive operations, the system cut cumulative CO_2 emissions by 780 tons (2024–2025), reduced average travel time from 45 to 18 minutes, and increased ridership by 10%, achieving 82% user satisfaction and recognition as the 2026 world's best sustainable transport system (Crux Alliance, 2026; Subúrbio, 2026).

4.2 Blue Highways

Blue Highways refer to the use of urban waterways as transport corridors, often combined with clean propulsion technologies such as electric ferries or hydrofoil boats, to improve system-wide transport efficiency. Driven by congestion and the revitalization of urban waterfronts, water transit is attracting growing interest. Ferry systems are expanding beyond traditional commuter and tourist routes to become an integral part of city transport systems. It supports modal shift from road to water leading to a behavioral shift.

Best practices

- Target congested corridors, where road congestion is high;
- Shift traffic from clogged roads to underused waterways;
- Integrate with public transport systems: ticketing, scheduling and intermodal connections;
- Adopt energy-efficient vessel technology such as hydrofoils which reduce drastically energy consumption compared to conventional diesel ferries and have small batteries which do not require massive charging infrastructure.

Notable examples include:

- Kitsap County, US: opening of 3 passenger fast ferry routes to Seattle: 37% increase in riders from 2022 to 2023;
- Washington State, US: aim for an emission-free electric boat fleet by 2050;
- Mumbai, India: development of hydrofoil ferries for popular tourist routes: cutting travel time on certain routes from 90 minutes by car to 30 minutes on the water.

Impact on people

Ferry commuting scores higher on customer satisfaction surveys than other modes of public transit. The use of these "forgotten highways" combined with electric hydrofoils enables for faster commute times, reduces noise and air pollution as well as being an attractive alternative to traditional modes of transport.

Limitations

- The use of Blue Highways is only applicable in cities with rivers, lakes, or coastlines;
- New vessels can entail high upfront costs;
- Integration challenges: requires coordination with land transport systems;
- Operations may be affected in some climates (weather and seasonality);
- Inefficiency of existing diesel ferries: 15-30 times more fuel per passenger mile than buses.

4.2.1 Case study nº5: Sweden – Stockholm Hydrofoil "Blue Highways" Initiative (see case study in Annex 5)

In 2024, Stockholm committed to improve transport energy efficiency and reduce congestion by shifting passenger mobility from road to water using electric hydrofoil ferries. Hydrofoil boats are now an integrated part of their public transport system. Early pilot results show that the boats use up to 80% less energy per passenger-kilometer compared to conventional ferries and emit 95% less CO_2. Some vessels have halved the commute time of a conventional diesel ferry on some routes.

5. Policies Focusing on Users

Technological advancements and infrastructure design are enhanced by user-oriented policies that incentivize reduced private vehicle use and improve the overall performance of low emissions transport networks. Within this pillar, we prioritized congestion, shared mobility, and modal shift as topics with a focus on accessibility, equity, and coalition building.

5.1 Congestion

Congestion policies mitigate excess demand for a limited supply of road infrastructure caused by rapid urbanization and higher rates of vehicle ownership. Incremental movement poses a major energy efficiency challenge, where driving at 10 km/h compared to 25 km/h halves fuel efficiency (ERIA, 2016). Ranging from regulation to incentivization, congestion policy tools are designed to redistribute traffic more efficiently and encourage a shift towards collective or lower-emissions alternatives. Regulations with a shorter timeframe for implementation include limiting road use to alternating days based on license plate numbers, such as Bogota's "Pico y Placa" policy. Congestion pricing is another option where drivers are charged higher prices for road use during peak demand periods.

Best practices

- Reinvest pricing scheme revenues in complementary infrastructure investments and measures to offset costs for disproportionately affected users;

- Integrate an equity lens to avoid or offset the regressive effects of congestion policies on lower-income populations who have lower capacity to absorb the cost or circumvent the regulation;
- Prioritize coalition building and grassroots engagement to break down informational barriers and generate local buy-in.

Impact on people

As the primary effects of congestion reduction, fewer cars in circulation and increased fuel efficiency decrease greenhouse gas emissions. Several co-benefits of smoother circulation include, but are not limited to: better air quality, reduced noise pollution, and fewer accidents (Singichetti *et al.*, 2021). In the context of global energy crises, congestion policies can return quick results. Shortly after implementing congestion pricing in 2003, Transport for London reported a reduction in circulating traffic by 15% and congestion by 30% within the designated zone in its second annual report (Transport for London, 2004). As road transport accounts for 45% of the global oil demand, congestion policies are a key lever in mitigating supply disruptions in the short term and transforming urban transport systems in the long-term (IEA, 2026).

Limitations

- As a regressive tax on mobility, congestion pricing and paid exemptions to congestion regulations risk exacerbating socioeconomic inequality (Börjesson, 2018).
- Without viable alternatives to high-traffic roads, congestion policies can increase travel times or displace car travel without generating real energy savings.
- New roadsharing dynamics may become unsafe without coordinated safety measures and information campaigns (Singichetti *et al.*, 2021).

5.1.1 Case study n°6: United States - New York's Central Business District Tolling program (see case study in Annex 6)

Following years of political gridlock and grassroots organizing, NYC's Central Business District Tolling program, the first program of its kind in the US, officially launched in January 2025. Within the Congestion Relief Zone (CRZ) in Manhattan, vehicles are charged a toll according to vehicle type, entry point, and discount eligibility. Within its first year of operation, the program resulted in 60,000 fewer vehicles in the CRZ daily, reduced GHG emissions, and reduced noise pollution. The toll revenues will be re-invested in specific infrastructure projects.

5.2 Shared Mobility

Shared mobility aims to increase the ridership of conventionally private vehicles to reduce the environmental and social impacts of single owner vehicles and energy intensity of passenger transport. Programs can take on many different forms, from privately owned vehicles increasing occupancy to fleets of vehicles being shared, with the same goal of increasing user access on an 'as-needed' basis while decreasing their carbon footprint relative to full vehicle ownership (Martinez et al, 2024). Shared mobility offers more flexible and transport options that can greatly expand traditional public transportation networks while better meeting user needs, especially those living outside of the conventionally served areas (An & Shen, 2025).

<u>Best practices</u>

- Focus on equitable access, through market research with socioeconomic focus;
- Engage with stakeholders at every level throughout the process, with community involvement to better understand user needs and program implementation challenges;
- Give instructions in different languages (when applicable);
- Target single car drivers rather than public transport users and pedestrians who may be more likely to shift away from their energy efficient mode of transport (An & Shen, 2025).

Impact on people

Network accessibility and freedom of movement is greatly increased through shared mobility, as previously inaccessible trips through public transport alone become possible. It supports car-free households, reduces congestion within cities and costs of owning a vehicle are saved by users (Martinez et al, 2024).

Limitations

- It may be harder to implement in rural areas as network sharing services struggle to operate in less dense areas, however regular trips, like commuting, can use shared mobility.
- Users of shared mobility options tend to be more affluent and well educated, leading to a divide in user prioritization for sustainable project revenue.
- Lacking community engagement and heavy reliance on technology for ride sharing access may lead to inequitable usage (Martinez et al, 2024).

5.2.1 Case study nº7: France - Lyon's carpooling as a public service (see case study in Annex 7)

In Lyon, spontaneous carpooling reached 25,000 users in less than a year and is now available to 1.6 million people in over 100 municipalities. Public subsidies ensure low or free trips for passengers. 85% depart in less than 10 minutes with an average waiting time of 4 minutes. For those not departing within 20 minutes (<5%), the insurance covers an alternative trip. The service is complemented by dedicated lanes on high occupancy roads, stations to pick up passengers, and parking spaces.

5.2.2 Case study nº8: United States – St. Paul's Car-sharing fleet (see case study in Annex 8)

In 2021, the city of St. Paul purchased 140 electric vehicles for the car-sharing fleet, the largest publicly owned one in the US, and built supporting EV charging stations throughout underserved communities. The public ownership of the fleet steered the project development to focus on transportation equity while electrifying. The project relied on widespread and local-level community engagement through NGOs to better understand user needs and improve program adoption in historically underserved communities.

5.3 Modal Shift

Modal shift refers to behavioral changes from high-emission to low-emission modes of transportation, the latter often being public and collective, but not always (privately-owned bikes for example). Modal shift can result from policies that directly aim to change travel modes as well as from policies targeting other goals and indirectly cause modal shift. Furthermore, successful strategies usually require comprehensive, system-wide policy changes.

Best practices

- Consider the hierarchy of public transport needs (Figure 4) and secure basic needs, such as high level of accessibility, before working on advanced needs, such as low environmental impact.
- Price services carefully: while affordability is key to high ridership, making public transport free can be counterproductive—shifting trips from walking or cycling, increasing costs for local governments, and risking overcrowding (Batty et al., 2023).

- Strive for a balance between policies that "push" users away from private cars (congestion pricing) and policies that "pull" users towards public transport (BRT, Blue Highways and Bike Lanes) to secure social and political backing;
- Address negative social perceptions of public and private transportation. Users generally overestimate the time of public transport journeys (Georgiardis et al, 2025) and underestimate the cost of maintaining private cars (Andor et al, 2020), undermining support for public transport.

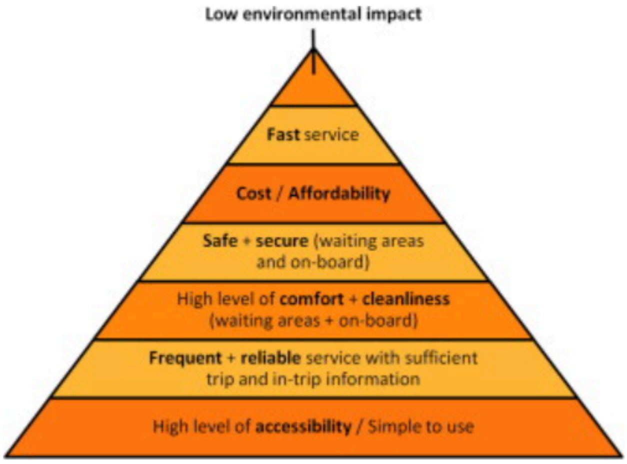

Figure 4: *Baty et al's pyramid of public transport needs.*

Impact on people

Modal shift contributes to national climate goals and generates large co-benefits, namely by decreasing air pollution and related public health issues, reducing road accidents and allowing for increased pedestrianization.

Limitations

- Successful modal shift policies should account for the needs of diverse categories of users. Caroline Criado Perez, in *Invisible Women* (2019), writes about how women are more likely to engage in "chain-trips," for instance to drop off children at school before getting groceries and visiting an elderly relative, while men mostly engage in home to work journeys. Ignoring this results in the high prevalence of star shaped public transportation systems that are ill suited for chain-trips.

5.3.1 Case study n°9: France - Paris's Plan Vélo Act 2 (see case study in Annex 9)

Paris's Plan Vélo II aims to create a 100% bikeable city through bike lane infrastructure expansions and ridership campaigns. In 2024, 11.2% of trips were made by bicycle, relative to 3% in 2010 and 15% reported declining car usage. Improved bike plans, clearer signage, more secure parking options to reduce theft are key system design improvements to encourage modal shift. Beyond physical infrastructure, Paris started 'learn to bike' programs in schools to create the next generation of cyclists and financial aids to equitably increase bike access.

6. Comparative Policy Analyses

6.1 Broader Policy Alignment for Each Case Study

Please see Annex 11 for a table summarizing the relevant regulatory frameworks and climate objectives anchoring the case studies analyzed in this report.

6.2 Policy Evaluation Matrix

Figure 6 below maps the policy interventions examined in this paper across five dimensions. For each dimension, policies are rated on a three-point scale, ranging from least favorable (red) to moderately favorable (yellow) and most favorable (green), based on criteria synthesized from the report findings and defined in Figure 5 below. The ratings for each dimension are independent of the others; a low score on cost (expensive) must be considered relative to the other dimensions.

	Description	Favorability Criteria | "Most Favorable"
Cross-Pillar Applicability	Integration of and/or benefits across multiple policy pillars (Technology, Infrastructure, User Behavior)	Policy applicable to all three pillars
Cost	The fiscal burden placed on the public sector or fundraising needs from private sector partners	Low upfront costs to implementation
Implementation Duration	The time and institutional capacity required to move from policy design through deployment	Quicker deployment possible with limited institutional setup
Return Timeframe	The lag between policy implementation and measurable emissions or efficiency gains	Emissions or efficiency gains materialize within a short timeframe
Co-Benefits	Secondary positive effects generated beyond the policy's primary energy efficiency goal	Generates numerous spillover benefits, including favorable health, equity, air quality, or economic outcomes

Figure 5: *Criteria description for the policy evaluation matrix.*

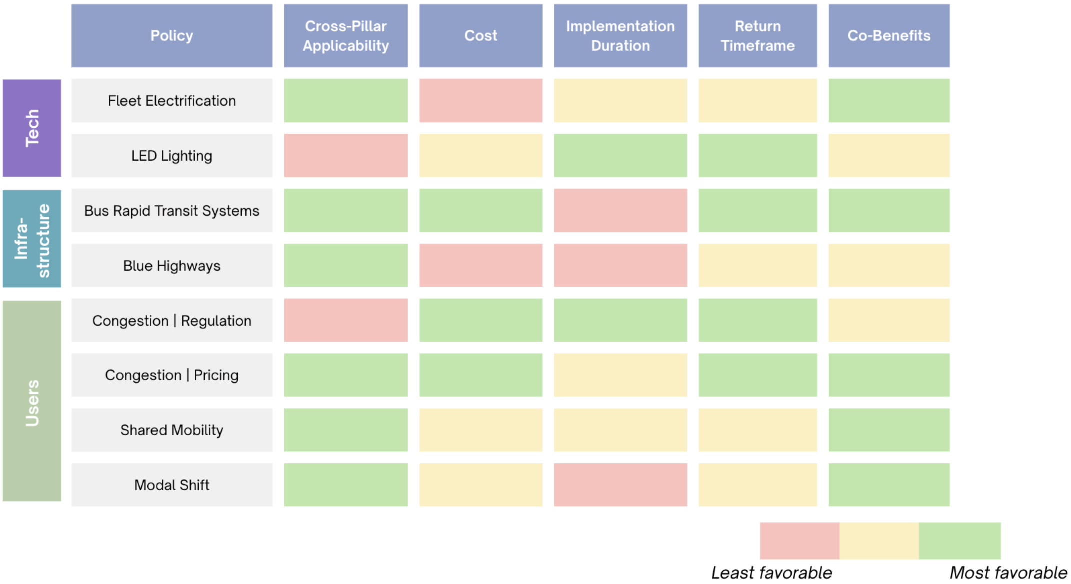

Figure 6: *Policy evaluation matrix.*

The trade-offs inherent in each policy are further informed by country contexts, where advanced economies must contend with the oil demand intrinsic to high passenger vehicle usage and emerging economies may need to prioritize acute accessibility gaps. Policy choice is also shaped by global dynamics. Energy crises and supply shocks will require fast-deploying interventions at the expense of co-benefits and people-centered design, whereas higher investment can lead to longer term returns with the added complexity of political obstacles and resource constraints. A successful strategy is one that effectively negotiates this tension to build transport systems that are both resilient and capable of systemic transformation.

7. Overarching Strategies for Achieving Energy Efficiency in Urban Transport

To maximize public support and ground efforts in local realities, cities must engage in consultations, information campaigns, and cooperation.

7. 1 Consultation

Consulting local stakeholders offers two key benefits:

1. Maintaining ambitious policies without creating unfair impacts on specific demographics, by addressing diverse needs.
2. Increasing local support: being able to shape the outcome critically increases social acceptance, especially when policies require behavioural shifts.

Effective consultation requires that stakeholders know that they can participate, how to do it and that their feedback matters. Methods include public hearings, dedicated websites for information and suggestion (as seen in the UK), and local assemblies modeled on the French climate citizen assembly.

7.2 Information campaigns

Information campaigns are critical for many urban transport policies, especially those requiring behavioral adaptation. Strategies include public display, local meetings, online diffusion, etc. and should highlight co-benefits to maximize social adherence.

For instance, the 'month without my car' initiative, growing globally, presents different alternatives to individual cars. It requires participants to forgo their car for a month while providing them with free access to public transport, bike sharing systems, etc.

7.3 Cooperation

Cities worldwide face similar challenges, offering opportunities to cooperate and learn from global successes and failures. Cooperation also facilitates replicability as cities can explore the goals and constraints behind policies.

Energy efficiency often overlaps with climate action, where learning from others is as vital as local action (Reckien, 2026). City cooperation evolves across two dimensions: geographic distance (adjacent vs distant) and leadership capacity (symmetric vs asymmetric).

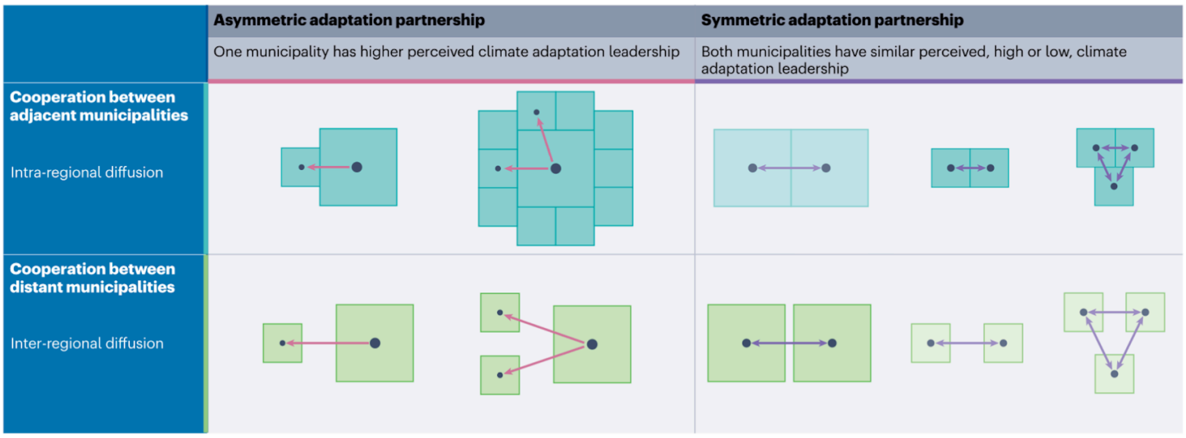

Fig. 1 | Four avenues of learning about adaptation in similarity-based partnerships. Partnerships are divided by geographical distance (adjacent versus distant municipalities) and by perceived adaptation leadership (asymmetric versus symmetric). Leadership is understood as the administrative, financial, technical or general organizational municipal resources that can act as problem-solving capacity for adaptation. Squares represent municipalities, with their size corresponding to the perceived level of climate adaptation leadership. Darker colours stand for relatively common forms of partnerships, while lighter colours show rare examples within a given avenue of learning. Arrows represent collaboration between municipalities. One-directional arrows indicate asymmetric partnerships, in which the tail lies in the municipality with higher perceived adaptation leadership and the arrowhead points to municipalities that receive technical, financial or other support from the perceived leader. Double-headed arrows indicate symmetric partnerships.

Figure 7: *Adaptation partnerships in cities (Source: Reckien, 2026). See Annex 14 for examples.*

Asymmetric partnerships, characterized by clear leadership, are powerful during crises. Symmetric partnerships, built on trust and shared ambition, are more effective for long-term systemic transformation, typically requiring around three years to show results.

This framework should encourage local policymakers to cooperate and select partnerships that better suit their risks, timeline and capacities.

8. The Importance of Comprehensiveness for Energy Efficiency in Urban Transport

Coherent integration of regulation, information, and incentives across technical, infrastructure, user, and overarching layers creates policy packages more effective than the sum of their individual policies. Clermont-Ferrand, France, exemplifies this through an ambitious political project to promote modal shift from individual cars to public transport.

<u>Layer 1: Vehicles</u>

To reduce GHG emissions, the city aims for 100% bus electrification by 2035. It uses on-route-charging to combine electrification benefits with the flexibility of a thermal fleet (see Case Study 2), and designs routes around main terminals and the city's topography. Older buses will serve distant roads until replacement.

Electricity for the two main bus lanes is generated locally via 18,000m^2 of solar panels on the bus depot (5 gigawatts/year). This exemplifies how strong political will can overcome high costs, here primarily driven by insurance and fire safety measures.

<u>Layer 2: Re-designing public spaces</u>

New bus lanes now connect 90% of inhabitants to essential services within 30 minutes, replacing the inefficient 'star-shaped model' (see Modal Shift). Accessibility is ensured through five specific services:

- RSVP transport for ten of the furthest communalities (the bus only operate if someone asks in advance);
- Dedicated RSVP transport for people with reduced mobility;
- Free night buses (Thursday to Saturday) connecting the city center to university campuses;
- Universal school bus access;
- On-demand bus stops after 10pm to enhance safety.

Public transport supply increased by 20%. Aware that supply-side management alone would not drive a modal shift, policymakers also redesigned public spaces. Some areas previously dedicated to cars, such as traffic lanes and parking, were reallocated to public transport, bike lanes, sidewalks, and greenery, with over 3,000 trees planted, reflecting the integration of energy efficiency and climate strategies.

To facilitate inter-modality (i.e. using different transport modes during the same trip):

- Bike-sharing stations, personal bike lockers, and 365km of bike lanes are being added by 2028.
- Park-and-ride facilities (free and dedicated parking spaces around the city with direct access to public transportation) are expanding to 4,000 spaces by 2030 (925 added in 2023), which are free for public transport ticket holders. Those multi-floor parkings incorporate green spaces and solar panels, reducing soil artificialization and producing green electricity.

See Annex 15 for maps of park-and-ride facilities & bike lanes and stations.

This strategy to encourage modal shift was effective as it combined reducing spaces for individual cars ('push' policies) *while* making alternatives efficient and affordable ('pull' policies). Some streets are restricted to residents or delivery services to be mindful of those who must still use cars.

Layer 3: Behavioral shift

Public transport is now free during the weekend, and the city introduced a bike sharing system that residents can use at no cost. It also offers long-term bike rentals (electric bikes, cargo, etc.).

Overarching layer:

Consultation: Over a 1.5-year consultation process, stakeholders could help refine the project to adjust it to their needs and constraints. Businesses impacted by roadworks were assisted and compensated when necessary.

Information: Businesses were made aware of the limited impact of roadworks on their revenues as less than 10% arrive by car in the city center. The city highlighted the multiple co-benefits, including less pollution (air, noise, visual), positive health impacts, affordability and a reduced carbon footprint. A 'street code' was also put in place to inform on the rights and duties of different users and there are plans to implement a biking school.

Cooperation: 23 surrounding cities were included into the consultation process and the transport system. The city also assists distant cities in drafting policies, especially regarding solar panels on bus depots.

9. Conclusion

Over the last decade, energy efficiency has become a central pillar of urban public transport. Rising energy demand and climate commitments have pushed policymakers to explore diverse mechanisms to make cities' transport systems more efficient.

In an effort to holistically address energy efficiency in urban transport, this report analysed three key pillars: 1) technological advances, 2) infrastructure and urban design, and 3) user behavior. The first encompasses technologies that reduce energy consumption and GHG emissions. The second focuses on how urban infrastructure can positively impact energy efficiency in transportation. The third addresses user behavior and the promotion of modal shift and shared mobility. Across these three categories, the central argument of this report holds: a comprehensive and participatory approach is essential for achieving meaningful and sustainable energy efficiency gains in urban public transport.

The analysis revealed that while many countries are advancing successful energy efficiency initiatives, not all are taking a sufficiently integrated approach to maximise their impact. Energy efficiency policies in transport are not mutually exclusive, but complementary. Technological advancement alone cannot deliver results if disconnected from the urban systems that bring it to people, and without the right incentives, behavioural change and the modal shift from private to public transport will not happen. The real challenge lies in implementing these three pillars in a coherent and mutually reinforcing way. Transport is, ultimately, a personal experience, and placing users' needs at the centre of implementation, supported by meaningful community and stakeholder engagement, is crucial for ensuring the long-term sustainability of these systems.

It is important to acknowledge what lies beyond the scope of this report, but should be considered by policymakers and researchers. Namely, transport between cities, freight, and transport in rural areas all have significant potential for change, and should be further explored.

Nevertheless, cities are at the forefront of implementing dynamic and ambitious energy efficiency policies for transport, and their potential for impact is enormous. Through the best practices examined in this report, we have seen how cities across both developed and developing countries are driving change at the local level, with effects that go well beyond energy savings. These initiatives are improving quality of life, expanding access to opportunities, and enhancing urban environments. More than a technical challenge, the transition to efficient public transport is also a social one: it is about building cities where public transport becomes a tool for integration, equity, and shared prosperity.

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11. Annex

Annex 1: Case Study 1 - Fleet Electrification - Rwanda

Case study nº1

Rwanda - Developing infrastructure and incentives to promote electric mobility

Country: Rwanda

Sector and approach: Transport - Regulation, Incentives, Information

Source: National Transport Policy and Strategy for Rwanda | Strategic Paper on Electric Mobility Adaptation in Rwanda

Objective

Provide incentives for EVs and charging infrastructure and raise awareness about associated benefits. Ensure safe, sustainable and accessible transport (for goods and people) while reducing dependency on fossil fuels in the transport sector by shifting to domestically generated electricity.

Results

In 2020, there was no electric bus in Rwanda. Now, 6% of the fleet is electrified. Savings of 20 billion Rwanda francs ($13 million) on oil importation up to 2025.

Unique aspects of the policy

Draws on the lessons learnt from the National Transport Policy of 2008 to promote an integrated multimodal transport system addressing cross-cutting issues (inadequate public transport, lack of facilities, poor road safety, lack of rural access, high cost and slow travel time, growing emissions of local air pollutants and GHG, lack of gender equality, etc.).

Draws on consultations with stakeholders to incorporate their needs and views into the final policy package.

Incorporates multiple co-benefits (protect the environment, ensure accessibility, reduce dependency on foreign importations for fossil fuels, decrease air pollution and health impacts, promote green development and innovation, low maintenance cost, create new jobs opportunities).

Follows multiple guiding principles (coordination, competition, cost recovery, efficiency, safety, universal access, environmental sustainability, resilience to climate change, leveraging the private sector, accountability, transparency, service delivery, value for money, autonomous decision making by City Authorities/Districts, smart transport).

Description

Policy directions: 1) develop required infrastructure to facilitate electric mobility and 2) put in place incentives to facilitate investment in electric mobility.

Fiscal incentives:

- Electricity tariff for charging stations capped at industrial tariff level;
- Reduced electricity tariff during off-peak time;
- Exempt EV, spare parts, batteries and charging station equipment from VAT tax, import and excise duties;
- Exemption of withholding tax of 5% at customs;
- Carbon tax to discourage polluting vehicles;
- Tax reduction on the Corporate Income Tax and the Tax Holiday for companies manufacturing and assembling EV.

Non-fiscal incentives:

- Rent government land for free for charging stations;
- Provisions of charging stations in building code and city planning rules;
- Grant EV preferential treatment (parking, green entry into congested zones, access to high occupancy vehicles lanes, etc.) through a green license plate;
- Free license and authorization for commercial EVs.

Administrative measures:

- Enforcement of existing emission standards to discourage the purchase of polluting vehicles;
- Create restricted zones for green transport;
- Regulate importation of used vehicles by imposing age limit;
- Provide preference to EV for government vehicles;
- Develop technical standards for EVs for the recycling of batteries and electronic waste;
- Establish a protocol of cooperation with countries and companies to facilitate technology transfer related to electric vehicles.

Alignment with the regulatory and policy frameworks

- Africa Agenda 2063: support Africa's accelerated integration and growth, technological transformation, trade and development by having the necessary infrastructure;
- East African Community's (EAC) Vision for 2050: improve ease of movement for people and goods;
- Rwanda Vision 2050: improve living standards and inclusiveness with transport as one of the main enablers of the vision;
- National Strategy for Transformation (NST1): use transport to spur national development and improve citizens' well-being;
- Sustainable Development Goals (SDGs): develop sustainable infrastructure to support economic development while ensuring affordability and equity for all;
- National Environment and Climate Change Policy: green mobility as a way to improve air quality and enhance access.

Implementation and enforcement

Document experiences on electric mobility and collect statistics to document progress.

Lessons learned

Importance of consultation, information campaigns and comprehensiveness of the plan.

Limitations and ways forward

- Cost: electric buses are 4 times more expensive than ICE buses (costs of battery and electricity need to be divided by 2), cost of electric cars needs to decrease by 15% to match non-electric ones.
    - Will be less significant as more EVs are produced because battery costs will go down.
- Charging infrastructures are not yet developed enough.
    - Incentives and measures to bridge the gap.
- Concerns regarding range and knowledge gaps.
    - EV advocacy to bridge knowledge gaps and common misperceptions.

Annex 2: Case Study 2 - Fleet Electrification - Madison, US

Case study nº2

United States - Madison city Electric bus fleet and overhead charging program

Country/Region/Province/City: Madison, Wisconsin, 2024

Sector and approach: Transport - Public procurement and infrastructure

Source: All-Electric Buses | Metro Transit | City of Madison, WI

Objective

The policy aims to reduce greenhouse gas emissions, fuel consumption and operating costs in the public transport sector by transitioning the municipal bus fleet from diesel to battery-electric buses. A key objective is to improve energy efficiency and air quality while maintaining reliable transit service, particularly in cold weather conditions.

Results

The city has upgraded its fleet to more than one-third all-electric vehicles. These buses have been more reliable for users than usual electric buses faltering with cold conditions providing a solution to transport disruption in extreme weather situations. Buses can travel up to 258 miles daily by topping off their batteries in just 15 minutes during scheduled layovers in routine stops.

Unique aspects of the policy

This policy stands out due to its use of overhead pantograph charging, allowing buses to recharge rapidly at route endpoints. This enables:

- Continuous operation without charging downtime;
- Smaller onboard batteries which improve efficiency and reduce costs;
- Optimisation for high-frequency urban routes.

It addresses challenges associated with stationary charging, including resource limitations, extended charging durations, and higher battery costs.

Description

In Madison, the public transport operator (Metro Transit) is deploying overhead charging systems for its electric buses using pantograph technology (also called opportunity charging or on-route charging). This system allows buses to recharge in minutes at route endpoints and operate continuously without long depot charging downtime.

This policy involves the progressive electrification of the Madison Metro Transit Fleet including:

- Procurement of battery-electric buses: 62 New Flyer electric buses were put to use in 2024;
- Installation of overhead charging stations at key transit hubs and terminals using inverting charging: a pantograph lowered from the charging station onto the current collector located on the vehicle's roof;
- Integration with existing routes and schedules: part of the bus rapid transit system (BRT) of the city.

Stakeholders include:

- City government (policy and funding);
- Metro Transit (operator);
- Technology provider (bus and charging infrastructure manufacturers);
- Utilities (electricity supply and grid integration).

Alignment with the regulatory and policy frameworks

This initiative aligns with local climate and sustainability plans, state and federal clean transport funding programs as well as broader US electrification strategies supported by the US Department of transportation.

Implementation and enforcement

Implementation is led by the city and Metro Transit through:

- Phased procurement of electric buses;
- Deployment of charging infrastructure;
- Monitoring of performance (energy use, reliability, costs).

The new electric vehicles were funded by the Biden Infrastructure Law (2021) and several federal grants.

Lessons learned

- Infrastructure planning is critical: charging systems must match route operations;
- Match charging strategy to route design: overhead charging works best for fixed, high-demand corridors;
- High upfront costs require external funding support;
- Grid coordination is essential for scaling;
- Electrification delivers the greatest benefits when focused on high-demand routes;
- Standardization efforts may be needed for compatibility between different pantograph systems and bus models;
- Flash charging technology can significantly reduce the need for large and costly on-board batteries, contributing to lighter, more energy-efficient E-buses.

Annex 3: Case Study 3 - LED - Jakarta, Indonesia

Case study nº3

Indonesia – Jakarta's switch to LED public lights

Country/Region/Province/City: Indonesia, Jakarta

Sector and approach: Transport - Infrastructure

Objective

Decrease energy costs from public lighting in Jakarta.

Results

Reduction of the power consumption by 78.43%, from 330,414 kWh to 71,278 kWh, with a payback period of 2.66 years.

Unique aspects of the policy

A smart system was put into place that allows for remote control and sharing of data, for instance which light is broken and where. Sensors were installed that allow for lights to be dimmed by 50% if low activity is detected, making the city possess one of the largest remote controlled street lighting systems at the global level.

Description

Replacing High-Pressure Sodium (HPS) lightbulbs with LED ones, installing sensors connected to a smart system that allows city officials to know the status of each lightbulb, as well as remotely control the level of brightness. Overall, 90,000 streetlights were replaced by LED, implemented in 7 months during 2016.

Alignment with the regulatory and policy frameworks

Indonesia's latest Nationally Determined Contributions commits to reaching carbon neutrality by 2060. Electricity and heat generation are highly reliant on fossil fuels and therefore represent the second largest source of emissions. As such, the IEA considers energy efficiency to be one of the three main levers for change, and indeed, recent regulations from the government go in that direction. These include the following examples:

- The Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 14 of 2021 concerning the Implementation of Minimum Energy Performance Standards for Energy-Using Equipment;
- Government Regulation of the Republic of Indonesia Number 33 of 2023 concerning Energy Conservation.

Annex 4: Case Study 4 - BRT - Salvador, Brazil

Case study n°4

Brazil – Salvador's Municipal Secretariat for Mobility - BRT System Expansion

Country/Region/Province/City: Brazil, Salvador

Sector and approach: Transport - Infrastructure

Source: **BRT - Prefeitura de Salvador**

Objective

Salvador's BRT system aimed to offer high-quality, energy efficient transportation by reducing congestion, travel time, and pollution.

Results

- New 7-kilometre route, bringing the BRT total to 12 km.
- Reduction of 780 tons of cumulative CO_2 emissions between 2024 and 2025 through the inclusion of electric buses.
- Average travel time reduced from 45 to 18 minutes.
- 82% of users are satisfied with the new service.
- Salvador's BRT was recognised as the 2026 world's best sustainable transportation system (Crux Allaince, 2026).
- 10% increase in BRT ridership demand.
- Average waiting time of 3 minutes.

Unique aspects of the policy

Rather than focusing solely on infrastructure, SEMOB sought to build a full ecosystem of efficient and inclusive transportation. Key features of the expansion include (Crux Alliance, 2026; Subúrbio, 2026):

- Fleet electrification: Introduction of electric BRT buses and the first electric charging terminals in Brazil, supported by a partnership with the World Bank for the acquisition of 100 electric buses;
- Multimodal integration: Connection with active mobility infrastructure, including bike lanes, bike and scooter sharing stations;

- Inclusive design: Elevators and level boarding for people with reduced mobility, alongside a gender perspective in staffing through the Women Behind the Wheel programme and gender-balanced security staff;
- Safety: 24-hour station surveillance and gender-balanced operations staff.

Description

Salvador's BRT operates 2 lines connecting 9 areas of Salvador, serving communities not reached by the metro, positioning the BRT as a complement to existing public transport rather than a replacement. The project directly benefits approximately 340,000 daily public transport users by reducing commuting times, improving safety, and alleviating traffic congestion.

Alignment with the regulatory and policy frameworks

- Brazil's National Urban Mobility Policy (Lei nº 12.587/2012);
- Salvador's Urban Mobility Plan (PlanMob);
- REFROTA programme (Urban Public Transport Fleet Renewal Programme);
- Salvador's Cycling Plan (targeting 780 km of cycling infrastructure by 2034).

Implementation and enforcement

The BRT system is implemented and overseen by SEMOB, which manages operations and monitors performance indicators. Station operations and maintenance are carried out through private sector concessions (Frotacia, 2022).

Lessons learned

- Salvador's BRT expansion illustrates how, when combined with fleet electrification and shared mobility policies, BRT systems can have a significant impact on energy efficiency in urban public transport.

Annex 5: Case Study 5 - Blue Highways - Stockholm, Sweden

Case study nº5

Sweden – Stockholm Hydrofoil "Blue Highways" Initiative

Country/Region/Province/City: Stockholm, 2021

Sector and approach: Transport - Incentive

Source: Välkommen till Region Stockholm - Region Stockholm

Objective

Improve transport energy efficiency and reduce congestion by shifting passenger mobility from road to water using electric hydrofoil ferries. Reduce urban road congestion, lower transport emissions and provide fast, energy-efficient alternatives to car commuting and traditional road-based networks.

Results

Early pilot results show that the boats use up to 80% less energy per passenger-kilometer. compared to conventional ferries and emit 95% less CO_2. The hydrofoil technology lifts the boat above water, drastically reducing resistance and energy use. They have significantly reduced travel time and proved to be very popular with ferries being often fully booked. Some vessels have halved the commute time of a conventional diesel ferry on some routes.

Unique aspects of the policy

Stockholm was the first to use these electric hydrofoil ferries. Hydrofoil boats are now an integrated part of their public transport system. The policy combines electrification, modal shift and infrastructure optimization. This policy aims at getting car commuters to switch to waterborne transport. The boats also avoid the need for costly dock equipment, as it can charge using a regular car fast charger.

Description

The pilot project was run by Candela, Trafikverket, and Region Stockholm (SL) and implemented in 2024. Due to its success, the service has since been renewed and expanded.

The policy consists of:

- Deploying electric hydrofoils ferries on key commuter routes;
- Integrating ferry services into public transport ticketing systems;
- Using waterways to bypass congested road networks.

Alignment with the regulatory and policy frameworks

The initiative aligns with Sweden's national climate targets and EU sustainable mobility policies promoted by the European Commission.

It complements:

- Public transport expansion;
- Electrification strategies;
- Congestion reduction policies.

Implementation and enforcement

The project was implemented following a pilot-based approach. Plans are now under way to scale up boat production to meet increasing demand in the city. Region Stockholm monitors energy consumption, ridership and travel time improvement of the implementation.

Lessons learned

- Geography matters in this case;
- There are high upfront costs for new technology;
- Requires integration with land transport to maximise impact and works best when integrated into multimodal systems (MaaS, BRT…).

Annex 6: Case Study 6 - Congestion - New York, US

Case study nº6

USA – New York's Congestion Pricing

Country/Region/Province/City: New York City, USA

Sector and approach: Transport - Incentives

Source: [Congestion Relief Zone Tolling Program]

Objective

New York City's Central Business District Tolling Program, also referred to as the NYC Congestion Relief Zone Tolling Program, went into effect on January 5, 2025 as a product of extensive local-level activism and interstate cooperation. Managed by the Triborough Bridge and Tunnel Authority (TBTA), the program charges a toll on vehicles entering the Congestion Relief Zone (CRZ), defined as Manhattan south of and inclusive of 60th Street, but excluding FDR Drive, the West Side Highway, and any surface roadway portion of the Hugh L. Carey Tunnel connecting to West Street. The primary objective of this policy is to "unlock" gridlock for a city that "moves faster, breathes easier, and works better" (MTA, 2026).

Results

In the first year of implementation, the Metropolitan Transportation Authority (MTA) reported a variety of metrics detailing the program's far-reaching impact on areas like traffic, street safety, and revenue generation. Some key statistics from the first-year impact report are included below (MTA, 2026):

- 60,000 fewer vehicles entering the CRZ everyday, amounting to a 10% reduction;
- 4% more pedestrians walking in the CRZ, contributing to higher retail activity;
- $48 million generated during the program's first month, consistent with the $500 million target for the program's first year;
- Total estimated GHG emissions in the CRZ, as a function of vehicle volumes in the area, was 6.1% lower through the third quarter of 2025, as compared to 2024.

Early findings on reduced commute times, smoother and more reliable city transport, improved air quality, reduced noise pollution, and increased business activity are reflected in improved public opinion of the program since its implementation. In the midst of the Trump administration's attempt to stop the program in February 2025, a poll found that 42% of NYC residents were in favor of the program staying, compared to 35% in opposition. These statistics showed significant movement from a December 2024 poll that found 32% of respondents in favor compared to 52% opposed (Marcelo, 2025).

Unique aspects of the policy

Following in the footsteps of congestion pricing schemes implemented in London, Singapore, and Stockholm, New York City's congestion pricing scheme incorporates several features distinguishing it from comparable programs. Most significantly, this policy is the first cordon-based congestion pricing program in the United States, breaking through decades of political deadlock and serving as a potential model for other American cities. Under the Traffic Mobility Act underpinning the program, the net revenues, targeting $15 billion, are held in a dedicated capital lockbox fund to be re-invested into infrastructure projects, including system improvements, asset repair, and commuter accessibility upgrades (Jones *et al.*, 2019). This formal fiscal mandate ties congestion management to complementary transit investment in a way that few international precedents have done as formally. The toll costs are structured in tiers based on vehicle type, time of day, payment method, and entry point to ensure dynamic, demand-driven pricing. From a political perspective, the program has successfully overcome several political and legal barriers, facing a pause in its implementation followed by a revival and downsizing before a failed federal veto attempted by the Trump administration. The eventual successful implementation of the program and demonstrated effectiveness in its inaugural year demonstrate the importance of local and state-level coalition building and consultation in enacting socioeconomically responsive and locally grounded solutions to urban congestion solutions.

Alignment with the regulatory and policy frameworks

State-level policy frameworks:

- MTA Reform and Traffic Mobility Act (2019) as the primary enabling legislation, passed by the New York State legislature. This authorised TBTA to design, develop, build, and operate the Central Business District Tolling Program.
- Climate Leadership and Community Protection Act (CLCPA): Section 7.2 of the CLCPA requires the Governor and New York State agencies, including the NY State Department of

Transportation and the MTA, to act in a manner consistent with statewide greenhouse gas emissions reduction goals.
- New York State Constitution, Article XIV: A 2021 state constitutional amendment guaranteeing every person "a right to clean air and water, and a healthful environment."

Enabling and authorization mechanisms at the federal level:

- Value Pricing Pilot Program (VPPP): Authorization mechanism requiring comprehensive impact assessment for proposed policies addressing roadway congestion either using federal funds or impacting federally-funded infrastructure.
- National Environmental Policy Act (NEPA): Requires environmental review as a condition of federal approval, triggered by proposed tolling on federally-funded roads.

Implementation and enforcement

Toll collection is managed electronically, with incentives in place for drivers to opt into the electronic E-ZPass system. Drivers with an E-ZPass are charged automatically, while those without the device are charged more to receive a bill by mail. The toll structure is tiered, with passenger vehicles charged $9 during peak hours and 75% less overnight, while trucks, buses, taxis, and for-hire vehicles adhere to specific rate schedules (MTA, 2025). This structure ensures that the pricing is proportionate to the varying degrees of congestion different vehicle types contribute to. Discounts and exemptions are integrated into the enforcement framework for low-income drivers, people with disabilities, emergency vehicles, and certain government vehicles. For eligible low-income drivers, a 50% discount is available after the first 10 tolled trips in any calendar month, complemented by the “Fair Fares NYC” program that provides low-income residents with 50% on metro and bus services (Deutsch-Gross, 2025).

Lessons learned

By prioritizing cost-efficient management, structuring pricing in demand dynamics, and integrating a systems-based, people-centered approach, New York’s congestion pricing scheme has made great strides in comprehensively addressing congestion in one of the densely populated cities in the world.

The program would not exist in its current form without the tireless efforts of grassroots coalitions, including The Riders Alliance and the Tri-State Transportation Campaign. These organizations promoted mutually reinforcing benefits on the economic, health, commute times, and overall quality of life and combatted misinformation among affected residents and commuters alike.

Annex 7: Case Study 7 - Shared Mobility - Lyon, France

Case study nº7

France, Lyon's carpooling as a public service

Country/Region/Province/City: Métropole Lyonnaise, France

Sector and approach: Transport - Incentives

Source: Sytral Mobilités

Objective

Turn cars into a collective transport system to enable people who do not have access to public transport, mainly people in peri-urban or rural areas, to benefit from an efficient and fast transport system while decreasing their carbon footprint.

Results

In Lyon, the project was launched in March 2023 and reached 25,000 users in less than a year. As more cities are joining the initiative, this service is now available to 100 municipalities and to almost 1.6 million people. On average, passengers wait around 4 minutes at a carpooling station, 85% depart in less than 10 minutes and less than 5% don't depart at all.

Over the different carpooling lines created in France

- 90% of users were not carpooling before
- 21% of demotorization (the reduction of the number of cars owned per household)
- Cost reduction: almost 1300 euros each year for a regular passenger and almost 800 euros each year for a regular driver

Unique aspects of the policy

Ensures safety for all users by verifying each profile and through dedicated assistance.

Ensures that the trip will take place, if a passenger has to wait more than 20 minutes, the assistance intervenes to find an alternative trip and pays for it (taxi, bus, etc).

Ensures low pricing (often even free).

	Driver	Passenger w/ public transport subscription	Passenger w/o public transport subscription
0-5 km	1 euro per passenger	1 euro per trip	1 euro per trip
5-20km	2 euros per passenger	free (financed by the localities)	0,5 euro per trip financed by the localities)
20-30 km	2 euros per passenger + 0.1 euro per km beyond the 20th km	free (financed by the localities)	0,5 euro per trip financed by the localities)
30+ km	2 euros per passenger + 0.1 euro per km beyond the 20th km	0,1 euro per km beyond the 30th km	0,5 euro per trip + 0,1 euro per km beyond the 30th km

Table 1: Price of the carpooling service for different trips.

Description

Collaboration of cities to delegate some public transport competencies to Sytral Mobilités, an organism that is governed by elected officials from different cities around Lyon.

Complements public transport by transforming cars into a collective transportation system.

Provides dedicated lanes on high occupancy roads, dedicated stations to pick up passengers and dedicated parking spaces.

Connects passengers to drivers through a mobile application but does not require to book the trip in advance. Drivers upload their trip while passengers can signal where they are and where they want to go.

Alignment with the regulatory and policy frameworks

Plan National Covoiturage du Quotidien: A French plan to accelerate the deployment of carpooling for everyday use. It mobilizes 150 million euros to support carpooling by:

- Distributing a 100-euro-bonus for drivers (25 euros after the first carpooling trip and 75 euros after the 10th trip);
- Supporting local authorities in incentivizing carpooling (1 euro from the State for 1 euro spent by local authorities);
- Financing preliminary studies and the building of both stations and lanes of carpooling.

Annex 8: Case Study 8 - Shared Mobility - St. Paul, US

Case study nº8

United States, St. Paul's Car-sharing fleet

Country/Region/Province/City: St. Paul - Minneapolis, Minnesota, USA

Sector and approach: Transport - Information/Incentive

Sources: Interviews with Amy Brendomen & Russ Stark (See Annex 17), HOURCar.org

Objective

Expand the car-sharing service fleet with electric vehicles through public vehicle ownership and build out the complementary EV charging network, with special attention on accessibility in underserved communities.

Results

In 2024, the car sharing service provided 191,600 trips, with 90% of those trips in EVs. The fleet comprises 140 city-owned electric vehicles and 130 NGO owned vehicles (mix of ICE, hybrid and electric vehicles). 3 out of 4 of the car share users reported selling or deferring purchasing a vehicle due to the program. User demographics in 2025 reflected the targeted outreach with 58% of users classified as low-income and 40% as Black, Indigenous, and people of color (BIPOC).

Unique aspects of the policy

EVie Car Share, the publicly owned EV fleet, was the first 100% electric, city-owned fleet in the United States. The policy enabled public ownership of vehicles with a guiding focus on equitable program implementation through a pre-existing NGO car sharing network. The insurance on the vehicles is covered by the NGO through rider fees charged per trip. The policy paired the EV fleet expansion with EV infrastructure buildout, the EVie Spot network, in collaboration with the electricity utility in the area (Xcel Energy). The policy bridged the gap between large scale investments from federal grants and philanthropic donations with underserved stakeholder engagement and eventual network use. Using incentives, such as waived meter fees, to increase ridership as well as offering more languages for app use and outreach for better accessibility.

Description

In 2021, the city of St. Paul purchased 140 electric vehicles to add to the already existing fleet of 130 shared-cars and partnered with Xcel Energy to add 70 city-owned charging stations across St. Paul and Minneapolis. The initial funding came from the US Department of Energy, The Inflation Reduction Act, Bloomberg Philanthropies through the American Cities Climate Challenge and local fundraising.

Alignment with the regulatory and policy frameworks

The Inflation Reduction Act (2022) and Bipartisan Infrastructure Law (2021) expanded programs and initiatives to equitably build out EV charging and EV access. Under the US Department of Transportation (DOT), the Congestion Mitigation and Air Quality Improvement Program (CMAQ) which aims to meet the Clean Air Act (1963), granted funding for the project. On the city-level, the St. Paul Climate Action and Resilience Plan (2019) outlined carbon neutrality goals by 2050, with equitable car sharing named as a means for carbon reduction. The Minneapolis Transportation Action Plan (2020) aims to reduce carbon intensity of transportation while offering a wide range of transport options, including shared mobility and encouraging the usage of EVs. Equitable and environmental commitments of the carsharing public expansion aligned with federal and city-level goals.

Implementation and enforcement

- Used an existing network of community NGOs and community groups for more consistent and impactful outreach.
- City control of street parking and placement of charging stations.
- Consistent outreach and data monitoring of trip characteristics to better understand user needs and improve service.

Lessons learned

- Costs associated with charger maintenance scale quickly and wire theft was a prominent issue at first. The city required copper scrap to be sold by licensed sellers and theft decreased.
- Cross city collaboration, in this specific geographical area, with similarly aligned equity and transportation goals, greatly increased the program's impact and models how public ownership can be far reaching.

Annex 9: Case Study 9 - Modal Shift - Paris, France

Case study nº9

France – Paris Velo Plan II

Country/Region/Province/City: Paris, France

Sector and approach: Transport - Information/Incentive

Source: Plan Vélo II, Une Ville 100% Cyclable

Objective

Make Paris a '100%' bikeable city and increase the modal share of biking by addressing safety concerns and accessibility challenges. Paris expanded the bike lane infrastructure throughout the city and improved bike parking security to make biking safer and reduce theft, key barriers for modal shift.

Results

In 2024, 11.2% of trips were made by bicycle, relative to 3% in 2010, while only 4.3% of trips were by car. Bike lane usage also increased around 34% from 2020 to 2024 and 15% of Parisians reported declining car use.

Unique aspects of the policy

- Established permanent bike lanes from 'coronapistes' which were originally installed as temporary bike lanes during COVID-19, creating some key 'car-free' avenues through the city.
- 60km of 'olympistes' bike lanes specifically built for the 2024 Paris Summer Olympics were added, further expanding the network and recharacterizing Paris as a global biking city.
- Educational approach with programs to teach school children 'how to ride a bike' to establish the next generation of riders.
- Financial subsidies for new electric bikes and bike maintenance costs.

Description

The Plan Velo I (2015-2020) and II (2021-2026) created over 1,000km of bike lanes across the Paris region while decreasing the accessibility and speed for cars. The bike lanes are organized along the high traffic city corridors through the Velopolitan network which expands beyond the city limits and integrates far reaching train access. The secondary network connects these routes through inter-arrondissement lanes for trips above 1km and is complemented by a local network to enable bike travel on every street. Expanded bike parking options and security.

Alignment with the regulatory and policy frameworks

France's National Plan Velo & Loi d'Orientation des Mobilités (2019) aims to increase cycling's modal share from 3 to 9% by 2024 and help municipalities fund biking infrastructure projects, including Paris. The LOM has decarbonization goals and reduction of energy intensive modes of transport, aligning with the modal shift to cycling.

Implementation and enforcement

Tracking of bike usage and traffic patterns to better understand user needs through more advanced data collection that was considered when expanding the network. Followed crash statistics to better address and justify removing cars and installing barriers. Cooperation across citizen, transport, and commercial stakeholders for better project implementation and management.

Lessons learned

Modal shift comes from the culmination of factors and attitudes, not just improving infrastructure. Public opinion at first may be negative, like with 'coronapistes', but permanent installment allows time for meaningful adaptation.

Annex 10: Charging Technologies Options

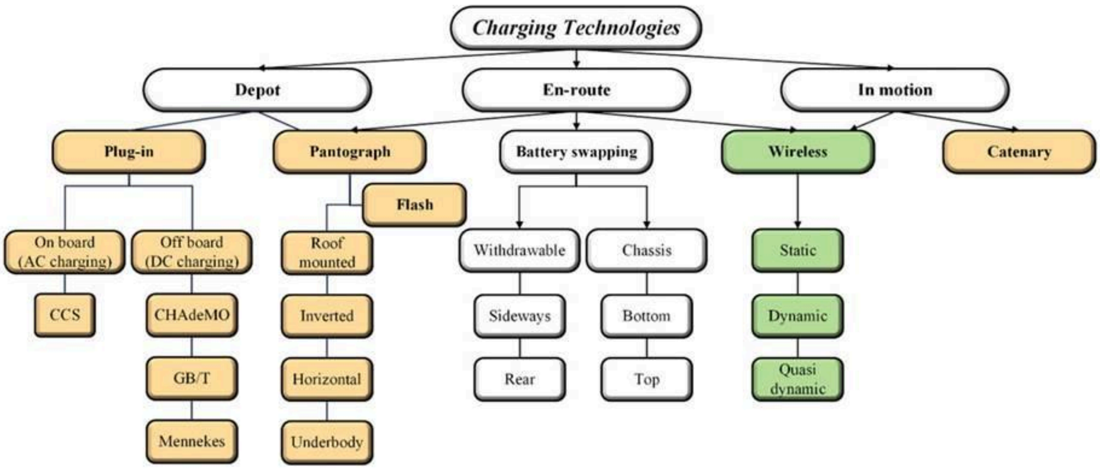
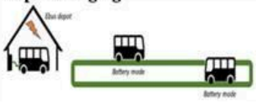
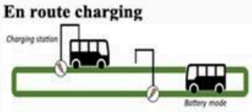
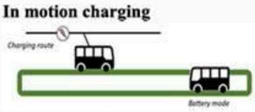


FIGURE 4. Current E-bus charging methods. The yellow boxes show conductive charging techniques, whereas the green ones show inductive charging methods.

TABLE 5. Main specifications of three charging modes; depot, en route, and in motion charging.

Charging method	Charging time	Power range (kW)	Fleet size	Electricity cost	Grid impact	Space need	Battery size	Dwell time
Depot charging 	4-8 hours	22-350	High	Low (charged at nights)	Low	High	High (~500-250 kWh Weight: ~5000-2500 kg Volume: ~2.5-1.25 m3)	High
En route charging 	20 sec-8 min	150-600	Average	High	Very high	Small	Low (~50 kWh Weight: ~ 500 kg Volume: ~0.25 m3)	Small (delay in some stations)
In motion charging 	While moving	up to 250	Small	High	Medium	Zero	Low (~30 kWh Weight: ~ 300 kg Volume: ~0.15 m3)	No extra delay

Source: Ashkezari et al., 2024

Annex 11: Broader Policy Alignment for Each Case Study

Broader Policy Alignment

Fleet Electrification	Rwanda	- Africa Agenda 2063: support Africa's accelerated integration and growth, technological transformation, trade and development by having the necessary infrastructure - East African Community's (EAC) Vision for 2050: improve ease of movement for people and goods - Rwanda Vision 2050: improve living standards and inclusiveness with transport as one of the main enablers of the vision - National Strategy for Transformation (NST1): use transport to spur national development and improve citizens' well-being - Sustainable Development Goals (SDGs): develop sustainable infrastructure to support economic development while ensuring affordability and equity for all - National Environment and Climate Change Policy: green mobility as a way to improve air quality and enhance access
Fleet Electrification	Madison, United States	This initiative aligns with local climate and sustainability plans, state and federal clean transport funding programs as well as broader US electrification strategies supported by the US Department of transportation.
LED Traffic Lights	Jakarta, Indonesia	Indonesia's latest Nationally Determined Contributions commits to reaching carbon neutrality by 2060. Electricity and heat generation are highly reliant on fossil fuels and therefore represent the second largest source of emissions. As such, the IEA considers energy efficiency to be one of the three main levers for change, and

		indeed, recent regulations from the government go in that direction. These include the following examples: - The Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 14 of 2021 concerning the Implementation of Minimum Energy Performance Standards for Energy-Using Equipment; - Government Regulation of the Republic of Indonesia Number 33 of 2023 concerning Energy Conservation.
BRT	Salvador, Brazil	- Brazil's National Urban Mobility Policy (Lei nº 12.587/2012); - Salvador's Urban Mobility Plan (PlanMob); - REFROTA programme (Urban Public Transport Fleet Renewal Programme); - Salvador's Cycling Plan (targeting 780 km of cycling infrastructure by 2034).
Blue Highways	Stockholm, Sweden	The initiative aligns with Sweden's national climate targets and EU sustainable mobility policies promoted by the European Commission. It complements: - Public transport expansion; - Electrification strategies; - Congestion reduction policies.
Congestion	New York, United States	State-level policy frameworks: - MTA Reform and Traffic Mobility Act (2019) as the primary enabling legislation, passed by the New York State legislature. This authorised TBTA to design,

		develop, build, and operate the Central Business District Tolling Program. - Climate Leadership and Community Protection Act (CLCPA): Section 7.2 of the CLCPA requires the Governor and New York State agencies, including the NY State Department of Transportation and the MTA, to act in a manner consistent with statewide greenhouse gas emissions reduction goals. - New York State Constitution, Article XIV: A 2021 state constitutional amendment guaranteeing every person "a right to clean air and water, and a healthful environment." Enabling and authorization mechanisms at the federal level: - Value Pricing Pilot Program (VPPP): Authorization mechanism requiring comprehensive impact assessment for proposed policies addressing roadway congestion either using federal funds or impacting federally-funded infrastructure. - National Environmental Policy Act (NEPA): Requires environmental review as a condition of federal approval, triggered by proposed tolling on federally-funded roads.
Shared Mobility	Lyon, France	Plan National Covoiturage du Quotidien: A French plan to accelerate the deployment of carpooling for everyday use. It mobilizes 150 million euros to support carpooling by: - Distributing a 100-euro-bonus for drivers (25 euros after the first carpooling trip and 75 euros after the 10th trip); - Supporting local authorities in incentivizing carpooling (1 euro from the State for 1 euro spent by local authorities); - Financing preliminary studies and the building of both stations and lanes of carpooling.

Shared Mobility	St. Paul, MN	The Inflation Reduction Act (2022) and Bipartisan Infrastructure Law (2021) expanded programs and initiatives to equitably build out EV charging and EV access. Under the US Department of Transportation (DOT), the Congestion Mitigation and Air Quality Improvement Program (CMAQ) which aims to meet the Clean Air Act (1963), granted funding for the project. On the city-level, the St. Paul Climate Action and Resilience Plan (2019) outlined carbon neutrality goals by 2050, with equitable car sharing named as a means for carbon reduction. The Minneapolis Transportation Action Plan (2020) aims to reduce carbon intensity of transportation while offering a wide range of transport options, including shared mobility and encouraging the usage of EVs. Equitable and environmental commitments of the carsharing public expansion aligned with federal and city-level goals.
Modal Shift	Paris, France	France's National Plan Velo & Loi d'Orientation des Mobilités (2019) aims to increase cycling's modal share from 3 to 9% by 2024 and help municipalities fund biking infrastructure projects, including Paris. The LOM has decarbonization goals and reduction of energy intensive modes of transport, aligning with the modal shift to cycling.

Annex 12: Examples of Cross-Cities Cooperation

	Asymmetric	Symmetric
Adjacent	Freetown: collaboration with Western Area Rural District Council. Resulted in trees planting, flood management, and green job creation.	Denmark relies on a municipal adaptation network across all 98 municipalities. Results in mutual accountability and raising ambitions.
Distant	C40 Climate Change Leadership of the Global Covenant of Mayors. Results in structured pathways providing targeted expertise.	Rotterdam and Copenhagen exchange solutions as costal frontrunners. Barcelona and Paris partner on political and institutional alignment.

Source: Reckien, 2026

Annex 13: Maps of Park-and Ride Facilities and Bike Facilities in Clermont-Ferrand

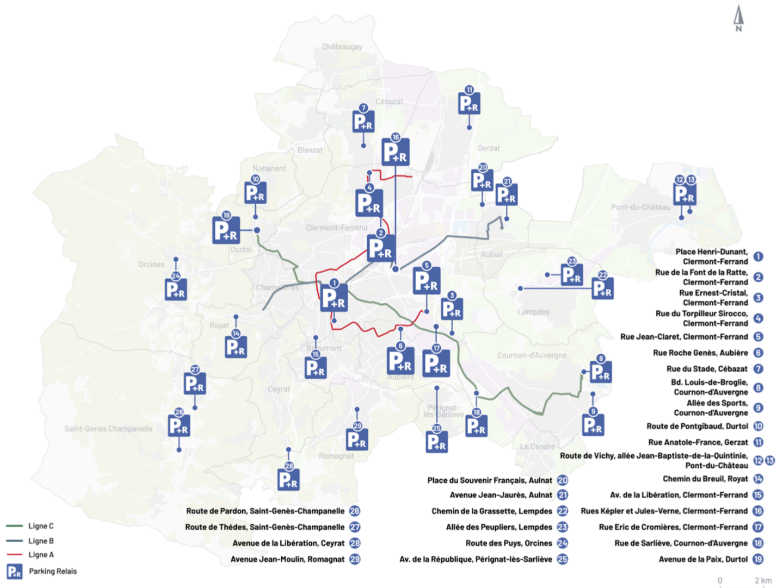


Figure 1: *Park-and-ride facilities in Clermont-Ferrand. (Source: Clermont Auvergne Métropole).*

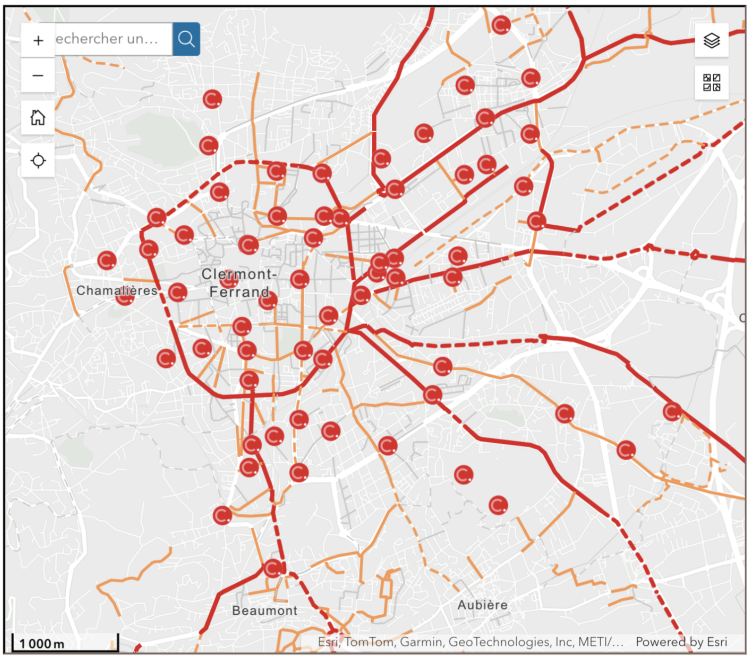


Figure 2: *Bikelanes and bike stations in Clermont-Ferrand. (Source: Clermont Auvergne Métropole).*

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Annex 14: Interview for Fleet Electrification - Rwanda

Corresponding case study: Case Study Number 1 - Fleet Electrification in Rwanda (see p. 8 and p. 35)

Interviewees: Theogene Dusabumuremyi - Director General in Charge of Transport at the Minister of Infrastructure in Rwanda & Janvier Twagirimana - In Charge of Green and Inclusive Mobility in the Transport Section of the Minister of Infrastructure in Rwanda

Interviewer: Chloé Toupet

Date of the interview: March 11th, 2026

Main takeaways:

- The main policy orientations for energy efficiency are to go green and reduce dependency on foreign fossil fuels. The government has at heart to respect its commitment to limit climate change as they are signatories of the Paris Agreement and are culturally inclined to protect a sane environment. Reducing dependency is a way to boost the national economy. From a historical perspective, they are attached to resilience, which is also a driver of their strategy.
- They are creating a regulatory framework to incentivize the adoption of electric mobility and push people to embrace these technologies.
- They are developing and electrifying the bus transport system to reduce emissions, save money, and reduce imports.
- They are also pushing for biking and walking as ways to reduce energy and oil consumption.
- Fleet electrification started in 2021: they have already electrified 6% of the fleet and aim to reach 100% by 2035.
- The replaced buses will be used for long transport or in cities where the fleet is not yet electrified.
- The project includes inter-ministerial cooperation.
- Mechanisms to monitor implementation are being defined.
- They are trying to stimulate both demand and supply for electric mobility.
- They use a wide range of policies and strategies, which range from campaigns of sensitization to sustainable procurement policy.

- Their current strategy is informed by what they learned from their previous strategies, reflecting a clear commitment to iterative policy-making.
- Sustainability across the whole supply chain remains a challenge, both in terms of availability of raw materials and their recycling or disposal. They have realized that this needs to be thought of at the regional level, as a country alone cannot deal with such high investments.
- Electric mobility is still nascent in Africa so it is really difficult to mobilize money but they are trying to create a conducive environment and work with different investors. The progress they are making, combined with technology maturing, will ensure that the market keeps becoming increasingly attractive.
- They have learned that adopting sustainable technologies requires effective communication and consultation. If people are not aware of the good policies they implement, they will have limited impacts.

Annex 15: Interview for Shared Mobility - Saint-Paul, US

Corresponding case study: Case Study Number X - Shared Mobility in St. Paul, MN (see p. 16 and p. 52)

Interviewees: Amy Brendmoen - Interim CEO of HOURCar & Russel Stark - Former Chief Resilience Officer of St. Paul.

Interviewer: Charles Wilson-Jackson

Date of the interviews: March 11th & 20th, 2026

Main takeaways:

- HOURCar, a non-profit organization, has a long history in the Twin Cities (St. Paul & Minneapolis) starting in the early 2000s as a community car sharing cooperative with around 20 vehicles. The fleet today is 270 vehicles, a majority of which are electric, and by 20230 the aim is for the entire fleet to be electric.
- The network offers users the ability to rent a car for up to 3 days, though most only use it for a couple of hours, and they can travel anywhere as long as the car is returned to the specific urban zone.
- The EVie Fleet is a fully electric city-owned fleet managed by HOURCar and operates within the same car sharing network. The city paid for the cars and HOURCar pays for the insurance which is covered by the fees charged to riders.
- The organization always had an equitable approach to access, and with the city partnership, those efforts were increased by targeting underserved communities with physical infrastructure and program awareness.
- Data is central to decision making and fleet management, with real time tracking of trip data and user needs. This data and surveillance also helps ensure safety while driving.
- Incentives are key for fleet management as users can help if vehicles need to be moved or washed.
- Community engagement was the cornerstone of the rollout, especially with the renewed focus on equity. Instructions in different languages helped expand access and the demographics of riders reflect the equity focus of the project.

Annex 16: Interview for Comprehensiveness - Clermont-Ferrand, France

<u>Interviewees:</u> Guillaume Astaix - Directeur Général de la SMTC (Syndicat Mixte des Transports en Commun) & Stéphane Panin - Directeur maîtrise d'ouvrage et grand projet, previous director of the Inspire project

<u>Interviewer:</u> Chloé Toupet

<u>Date of the interview:</u> April 3rd, 2026

<u>Main takeaways:</u>

- Their number 1 goal was to increase the share of public transport and reduce the use of individual private cars (without entirely suppressing it). This came from the realization that most trips made alone with an individual car could be made using other means of transport.
- They had to re-structure the entire transport network, as it had not been updated since 2006.
- They created a real supply choc by adding 20% of public transport to the existing network, but, aware that supply-side management alone is not enough for modal shift, they also re-designed public spaces to shift the focus from private cars to public transport.
- They combined strategies to constrain people to drive less with strategies to develop the alternatives, including re-dimensioning public spaces for bikers and pedestrians.
- Electric mobility was the best way to reduce GHG emissions. They chose on-route charging, to have an efficient electric system with fewer batteries, therefore limiting energy and space loss due to large amounts of batteries. The system is designed around the main stops and hills of the city.
- They are locally producing the electricity needed to power the main two bus lanes (5 gigawatts per year) through 18,000 m2 of solar panels installed on top of the bus depot and maintenance facility. This was the result of a tedious political battle, as there were important costs associated with this, mainly due to fire safety measures and insurance. Indeed, each bus costs around 1 million euros and solar panels are also expensive. This was a way for them to combine their energy efficiency strategy with reducing soil artificialization.
- Local energy production of energy is also a way to manage energy costs and reduce dependencies and vulnerabilities.
- They pointed out the importance of being able to anticipate national regulations.

- They explained how the energy crisis (after Russia's invasion of Ukraine) made the whole project harder, as they faced rising costs and delays in construction.
- By 2035, their 200 buses will all be electrified, if they don't face further delays.
- They explained that due to high costs and important delays, electric buses are not yet economically more attractive than thermal ones. Yet, they acknowledged that prices have been falling sharply.