EFFICIENT TRANSPORTATION:

An Action Plan for Energy and Emissions Innovation

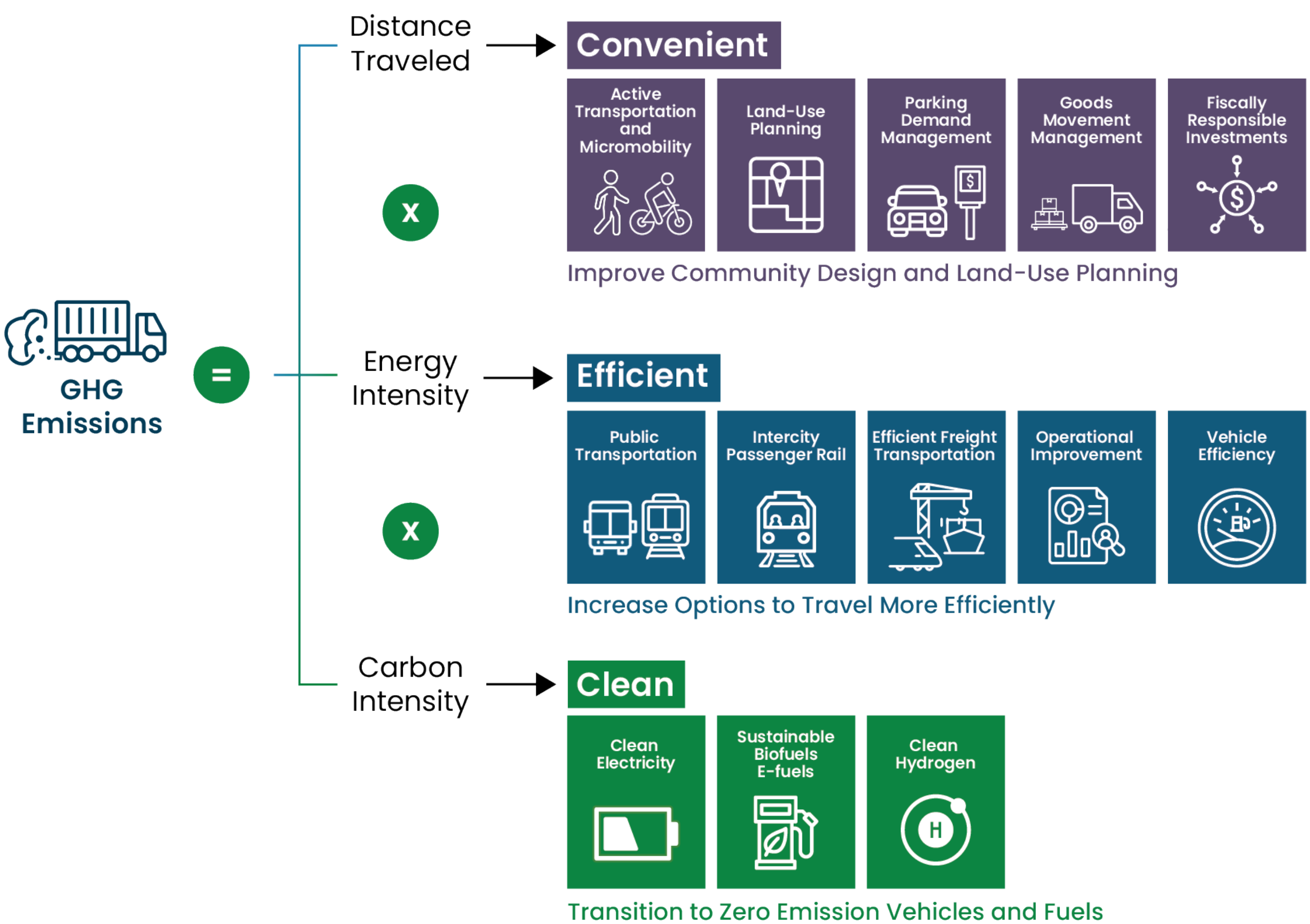
December 2024

DISCLAIMER

EXECUTIVE SUMMARY

The transportation sector is the largest source of greenhouse gas (GHG) emissions in the United States, responsible for one-third of all emissions. To address the growing climate crisis and to meet the goal of net-zero GHG emissions economy-wide by 2050, the United States must decarbonize transportation by eliminating nearly all GHG emissions from the sector.

The U.S. National Blueprint for Transportation Decarbonization (Decarbonization Blueprint) provides a framework to transition to a net-zero GHG transportation system through three interrelated strategies that tackle the main drivers of passenger and freight transportation GHG emissions: 1. Convenience *(distance traveled between destinations)* 2. Efficiency *(energy intensity of each mile traveled)*, and 3. Clean *(carbon intensity of the fuels)*. The Decarbonization Blueprint is the product of a unique cross-agency partnership between the Department of Transportation (USDOT), the Department of Energy (DOE), the Department of Housing and Urban Development (HUD), and the Environmental Protection Agency (EPA).



The Decarbonization Blueprint strategies of Convenient, Efficient, and Clean work to address the three main drivers of transportation emissions: distance traveled, energy intensity, and carbon intensity.

EFFICIENT | Increase Options to Travel More Efficiently

Public Transportation | Intercity Passenger Rail | Efficient Freight Transportation | Operational Improvement | Vehicle Efficiency

Public Transportation

- Increased funding
- Expanded and improved service
- First-mile/last-mile connections

Intercity Passenger Rail

- Increased funding
- Expanded and improved service

Efficient Freight Transportation

- Investments in rail and marine transport
- Intermodal freight facilities
- Emissions impacts of shipping options

Operational Improvement

- Using data and technology to optimize operations
- Reducing idling

Vehicle Efficiency

- Improving parts, materials, and performance of vehicles and infrastructure
- Fuel economy and GHG emissions standards
- Incentives to reduce vehicle size

The purpose of this Action Plan is to identify actions under the **Efficiency strategy** to realize the goal of decarbonizing the transportation sector by 2050. This plan describes actions that all levels of government and the private sector can take to reduce the energy intensity of travel. The federal agencies that developed this plan can have a major impact on improving transportation-sector efficiency and reducing emissions; therefore, this plan has a particular focus on federal actions. Recognizing the key role that state, local, and private sector entities play in realizing a more efficient transportation system, the plan also provides examples of successful actions these entities are taking.

Energy efficiency can be improved both within travel modes and systemwide across modes. The Efficiency strategy aims to reduce the energy intensity of transportation activities by enabling choices to shift to more efficient modes. For passenger transportation, this entails expanding more efficient options like public transportation and high-speed rail; for freight, it involves increasing the flexibility and choice of modes that are affordable, efficient, and meet shipping requirements, including rail and maritime transport. The Efficiency strategy also aims to improve the energy efficiency of individual vehicles within each mode and to improve transportation system operations.

To optimize benefits, the Efficiency strategy must be implemented in concert with the Convenience and Clean strategies. For example, expanding public transportation will be much more effective at reducing GHG emissions when combined with land use strategies that cluster jobs, shopping, services, and housing near transit hubs (Convenience) and with electric buses or rail (Clean). Companion action plans focus on the Convenience and Clean strategies; for more information and to download these plans when available, see the Decarbonization Blueprint website.

Carrying out actions within the Efficiency strategy will yield multiple benefits in addition to emissions reduction. These include household cost savings, supporting local economies and job creation, improved air quality and health, and increased accessibility and community connectivity. Investing in modes that do not require the expense of private car ownership enhances equity.

Efficiency actions yield substantial GHG reductions and additional benefits. For instance, EPA's vehicle emissions standards for new light-duty and medium-duty vehicles produced in model years 2027 to 2032 are expected to avoid more than seven billion tons of GHG emissions and provide nearly $100 billion of annual net benefits to society, including $13 billion of annual public health benefits due to improved air quality and $62 billion in reduced annual fuel, maintenance, and repair costs for drivers.[1] Investing in intermodal centers to allow freight to use more efficient modes such as rail and maritime for as long a distance as possible before needing trucking can reduce emissions substantially. An analysis of rail and ocean-going vessels in California found that their life-cycle GHG emissions per ton mile are 78 percent and 82 percent lower than trucking emissions, respectively.[2] A separate study found that barge GHG emissions are 89 percent lower per ton mile than trucking.[3] Research also shows that data-driven operational efficiencies at ports can reduce GHG emissions by 22 percent while at the same time lowering shipping costs.[4] Expanding public transportation service can reduce emissions significantly, while potentially also providing safety benefits: A Federal Transit Administration (FTA) analysis found that the number of fatalities per vehicle mile traveled in personal automobiles is more than three times that of buses, and more than twice that of heavy rail. Because transit vehicles have a much higher average occupancy than personal vehicles, the safety benefit of transit is even greater.[5]

The table below summarizes the key actions contained in this Efficiency Action Plan. These actions include continuing to implement and expand the federal government actions and initiatives currently underway, as well as realizing opportunities across all levels of government and the private sector. The table also includes key metrics to track and measure progress towards these goals.

Topic Area	Action	Lead	Key Metrics
Public Transportation	Implement Federal Transit Administration and other USDOT grant and loan programs supporting transit.	Federal (USDOT)	• Commute Mode Share • Transit ridership data
	Expand and improve public transportation service. This includes increasing availability, frequency, speed, reliability, efficiency, and comfort.	Federal (USDOT) Tribal, State, and Local Private Sector	
	Improve first-mile/last-mile connections to transit.	Tribal, State, and Local Private Sector	
	Use flex funding to expand available funds for transit projects, where appropriate.	State	
	Include provisions to encourage access to transit in green building certifications.	Federal (HUD)	
	Research mode shift effects of strategies to improve and expand public transportation.	Federal (DOE, USDOT)	
Intercity Passenger Rail Transportation	Implement Federal Railroad Administration and other DOT grant and loan programs supporting rail.	Federal (USDOT)	Intercity Passenger Rail Service Quality and Performance
	Develop high-speed passenger rail.	Federal (USDOT) Tribal, State, and Local Private Sector (including Amtrak)	
	Expand and improve intercity passenger rail service. This includes increasing availability, frequency, speed, reliability, efficiency, comfort, and effective connections to transit services.	Federal (USDOT) Tribal, State, and Local Private Sector (including Amtrak)	
	Research mode shift effects of strategies to improve and expand intercity passenger rail service.	Federal (DOE, USDOT)	

Topic Area	Action	Lead	Key Metrics
Invest in Efficient Freight Modes and Intermodal Facilities	Implement Federal Railroad Administration, Maritime Administration, and USDOT multi-modal grant programs. Implement USDOT loan programs.	Federal (USDOT)	Freight Movement by Mode
	Designate a National Multimodal Freight Network in 2024 that supports the use of and shift to lower carbon modes.	Federal (USDOT)	
	Consider emissions impacts of shipping options.	Private Sector	
	Develop intermodal freight hubs.	Tribal, State, and Local	
	Support safe and reliable freight railroad operations and infrastructure.	Federal (USDOT) Tribal, State, and Local Private Sector	
	Invest in inland ports and short sea shipping.	Federal (USDOT) Tribal, State, and Local Private Sector	
	Reduce freight and passenger rail conflicts to improve speed and reliability.	Private Sector	
	Research mode shift effects of strategies to improve and expand rail and maritime capacity. Model low-carbon intermodal freight transportation options.	Federal (DOE, USDOT)	
Improve Transportation System Operations	Implement EPA Clean Ports Initiative.	Federal (EPA)	• U.S. National VMT per capita • Energy Intensity of Freight Transportation • Energy Intensity of Passenger Transportation
	Implement USDOT Reduction of Truck Emissions at Port Facilities program and other programs that support operational efficiencies.	Federal (USDOT)	
	Fund research on operational efficiencies of emerging technologies.	Federal (USDOT, DOE, EPA)	
	Implement digital truck inspections to reduce idling at inspection stations.	Federal (USDOT)	
	Implement EPA SmartWay program.	Federal (EPA)	
	Develop regulations to reduce methane leaks from pipelines.	Federal (USDOT)	
	Develop and implement tools to optimize flight trajectories.	Federal (USDOT) Private Sector	
	Implement data sharing, digital platforms, and real-time freight and traveler information systems.	Federal (USDOT) Tribal, State, and Local Private Sector	

Topic Area	Action	Lead	Key Metrics
Improve the Energy Efficiency of Vehicles	Continue to set fuel economy standards for cars and trucks.	Federal (USDOT)	• NHTSA CAFE and EPA GHG Standards • Average Fuel Economy of U.S. LDVs in Use • Estimated Fuel Economy by Vehicle Type
	Continue to set vehicle emissions standards for cars and trucks.	Federal (EPA)	
	Develop, manufacture, and market highly efficient vehicles and vehicle components.	Private Sector	
	Agree on new stringency levels for the Airplane CO_2 Emissions Certification standard at the International Civil Aviation Organization in 2025 and adopt domestically.	Federal (USDOT)	
	Conduct research on improving vehicle efficiency.	Federal (DOE)	
	Develop and propose new locomotive emission regulations.	Federal (EPA)	
	Provide grants and research to replace old, inefficient locomotive engines with more efficient and low-emission technology locomotives.	Federal (USDOT)	
	Improve efficiency of ships through work with the International Maritime Organization.	Federal (USDOT, EPA)	
	Consider incentives to reduce vehicle size.	Tribal, State, and Local	

Achieving our goals will require all levels of government and the private sector to work together. State and local governments are already taking significant action to reduce emissions, from investing in new public transportation service to using technology to optimize traffic flow. Meanwhile, the private sector is rising to the challenge of producing highly efficient vehicles, optimizing intermodal routing, and more. The federal government is supporting this work with investments, research, and policy. We must redouble our efforts to address the climate crisis. It is up to all of us to make the vision of a sustainable future a reality and move forward with innovative solutions toward a better future for all.

ACKNOWLEDGMENTS

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The following individuals were responsible for the overall leadership and vision behind this action plan:

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CONTENTS

1. INTRODUCTION AND CONTEXT

1.1 A Vision for Transportation Decarbonization

The transportation sector is the largest source of greenhouse gas (GHG) emissions in the United States, responsible for one-third of all emissions. These emissions contribute to the global climate crisis, which is leading to rising temperatures, rising sea levels, and extreme weather events that are disrupting and damaging critical infrastructure, human health, property, and the vitality of our communities.[6] The effects of climate change disproportionately impact underserved and overburdened communities.[7]

To address the climate crisis and meet the goals defined under the Paris Agreement, the United States must achieve net-zero carbon emissions economy-wide—including from the transportation sector—by 2050. A well-planned transition to a sustainable transportation future will also result in a more affordable and equitable transportation system, with improved transportation services; more mobility choices; improved air quality and health; greater energy security; better quality of life and accessibility; enhanced access to a variety of housing options, services, and amenities; well-paying jobs; and safer, more vibrant and resilient communities throughout the country.

In response to the urgency of the moment, the groundswell of local climate action, and feedback from stakeholders, the United States Department of Transportation (USDOT), the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the Department of Housing and Urban Development (HUD) are coordinating their actions to decarbonize transportation, as directed by a 2022 Secretary-level Memorandum of Understanding. In January 2023, the agencies published their unified vision in the U.S. National Blueprint for Transportation Decarbonization (Decarbonization Blueprint).

The Decarbonization Blueprint provides a framework to transition to a net-zero GHG transportation system through three interrelated strategies that tackle the *main drivers* of passenger and freight transportation GHG emissions: 1. Convenience *(distance traveled between destinations),* 2. Efficiency *(energy intensity of each mile traveled)*, and 3. Clean *(carbon intensity of the fuels)* (see Figure 1).

- **Convenience:** An accessible transportation system with reduced distances between destinations for people and goods; freedom to use public transit and safe, connected sidewalks and bike infrastructure; and thriving, vibrant, affordable communities.
- **Efficiency:** Mobility options for people and goods, including public transportation, rail, and maritime travel, and reduced reliance on energy-intensive transport modes. The Efficiency strategy also involves improvements in the operation of transportation systems and the energy efficiency of vehicles.
- **Clean:** Deploying low- and no-emission vehicles, engines, and equipment alongside industry-wide electrification and investments in other clean fuel sources.

The systemic approach of all three strategies in the Decarbonization Blueprint is needed to meet our decarbonization goals and build a sustainable transportation sector. Through the 2021 Bipartisan Infrastructure Law (BIL), the 2022 Inflation Reduction Act (IRA), and the 2022 CHIPS and Science Act, Congress has provided unprecedented funding to reduce GHG emissions across the economy. With these resources, combined with preexisting federal transportation funding, the federal government can invest in decarbonizing the transportation sector. State, local, and private-sector action and leadership is also key to implementing the Decarbonization Blueprint strategies.

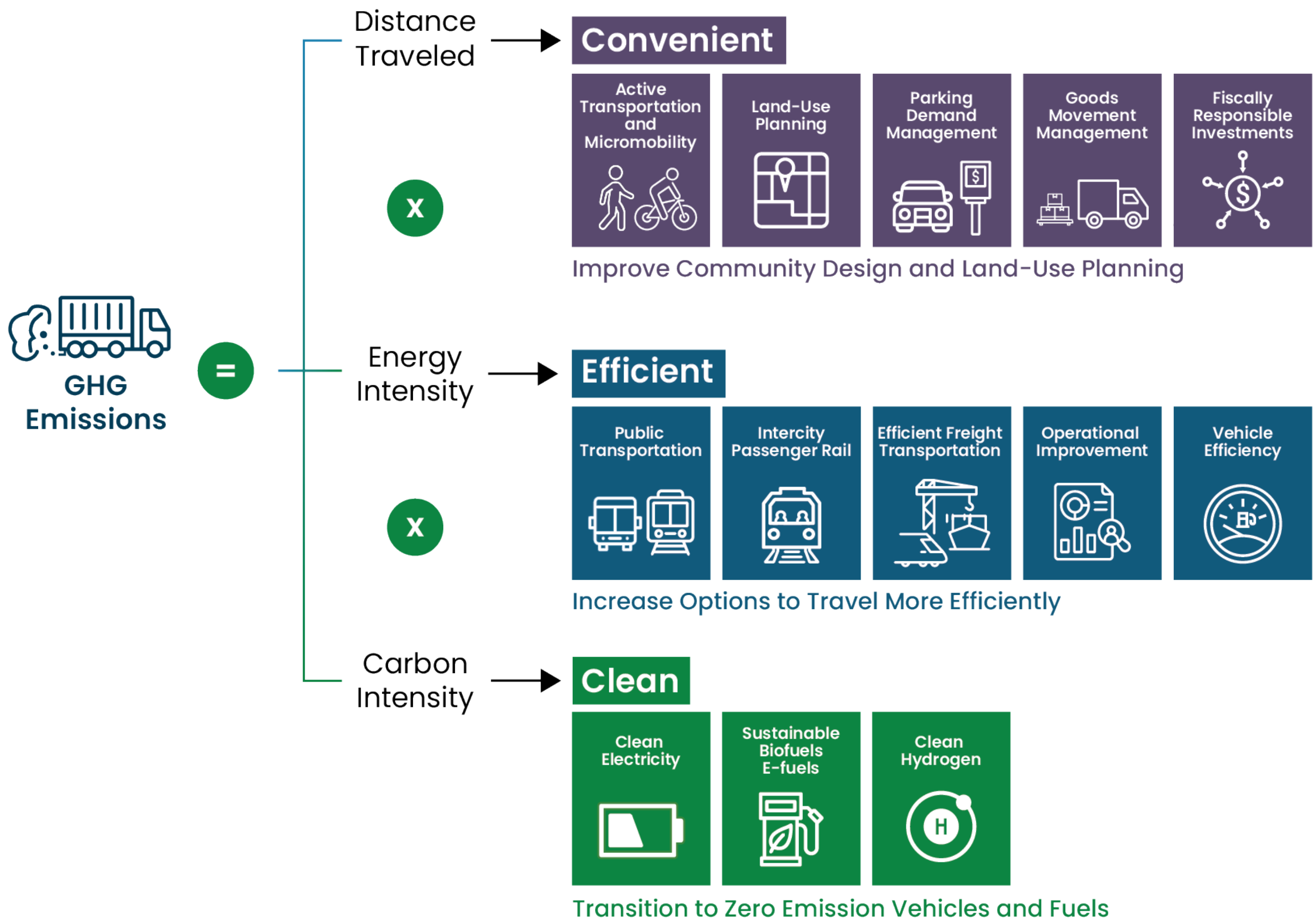


Figure 1: The Decarbonization Blueprint strategies of Convenient, Efficient, and Clean work to address the three main drivers of transportation emissions: distance traveled, energy intensity, and carbon intensity.

1.2 Efficiency Action Plan Purpose

The purpose of this Action Plan is to identify actions under the **Efficiency strategy** to realize the goal of decarbonizing the transportation sector by 2050. This plan describes actions that all levels of government and the nonprofit and private sectors can take to reduce the energy intensity of travel. The federal agencies that developed this plan can have a major impact on improving transportation-sector efficiency and reducing emissions; therefore, this plan has a particular focus on federal actions. The plan also provides examples of successful state, regional, local, and private sector strategies to improve efficiency. This plan is a vision document and a point of reference for stakeholders at all levels of government and across sectors; it should not be understood as a commitment by the federal government to carry out these actions or as a directive to state and local governments. The plan focuses on short-term actions that can be taken by 2030, as immediate GHG emissions reductions are needed to avoid the worst effects of climate change. Companion action plans focus on the Convenience and Clean strategies; for more information and to download these plans when available, see the Decarbonization Blueprint website.

An efficient transportation system is a key pillar of a better transportation system. Energy efficiency can be improved both within travel modes and systemwide across modes. The Efficiency strategy aims to reduce the energy intensity of transportation activities by enabling shifts to more energy-efficient modes. For passenger transportation, this entails shifts from personal vehicles to options like public transportation, micromobility, and shared vehicles, or from air travel to high-speed rail; for freight, it involves using rail and maritime transport where feasible. The Efficiency strategy also aims to improve the energy efficiency of individual vehicles within each mode and to improve transportation system operations. Actions included in the Efficiency strategy are grouped into the following categories:

1. **Public transportation:** Improve public transportation to make it a more safe, reliable and convenient choice for all travelers. Passenger travel by rail or bus has substantially lower emissions per passenger mile than travel by single-occupancy vehicles or air.[8]
2. **Intercity passenger rail transportation:** Shifting longer trips from less efficient modes to passenger rail can help reduce emissions from passenger travel.
3. **Investments in freight efficiency:** Shifting from trucking to more energy-efficient rail and maritime modes, where practical, is an important strategy to decarbonize freight movement.
4. **Improvements in the operation of passenger and freight transportation systems:** The operation of the infrastructure and vehicles that move goods and people can be improved and optimized to reduce energy use and emissions. This includes strategies such as optimized signal timing, real-time traffic data, improved freight scheduling, and more.
5. **Improvements in the energy efficiency of vehicles:** Improving the efficiency of all vehicle types (including cars, trucks, ships, buses, planes, and trains) through strategies like improved engines and other components such as HVAC and regenerative braking systems, more extensive use of lightweight materials, and hybridization will reduce GHG emissions and will benefit consumers and businesses, regardless of the type of vehicle used.

The Efficiency strategy focuses on reducing *energy intensity*, which is defined as the quantity of energy required per unit of output or activity.[9] For transportation, there are a few different ways to measure energy intensity.

Energy per passenger mile traveled measures the amount of energy it takes to transport one person for one mile and is used to compare the efficiency of passenger transportation modes such as cars, buses, trains, or ferries.

Energy per ton mile of freight transported measures the amount of energy it takes to transport one ton of freight one mile and is used to compare the efficiency of freight transportation modes such as trucks, rail, or maritime.

Distance traveled per unit of energy measures how far a vehicle can travel using a given unit of energy and is used to compare the energy efficiency of different vehicles. This metric is often used to communicate the fuel economy of cars; for gasoline-powered cars, it is frequently expressed as miles per gallon of gasoline.

2. ROLE OF EFFICIENCY IN REDUCING GHG EMISSIONS

2.1 Emissions Trends

In 2022, the transportation sector accounted for 33 percent of U.S. GHG emissions, representing the largest share of U.S. GHG emissions that year (see Figure 2).[10] In 2017, the transportation sector surpassed the electric power sector to become the largest direct source of U.S. GHG emissions. Transportation emissions increased steadily between 1990 and 2005. After peaking in 2005, transportation emissions fell during the recession of 2007 to 2009, rose through 2019, fell sharply in 2020 due to the pandemic, and have mostly rebounded since then but are still 7 percent below 2005 levels (see Figure 3). The GHG emissions increases are largely due to increased vehicle miles traveled (VMT) (see Figure 4).[a, 11]

Projections by the Federal Highway Administration (FHWA) and the 2023 Annual Energy Outlook (AEO) reference case published by the U.S. Energy Information Administration show this trend continuing, with passenger and freight VMT increasing through 2050. The FHWA forecast projects an average annual increase in VMT of 0.6 percent for all vehicle types from 2019 to 2049, or an approximately 20 percent increase over the 30-year period.[12] The AEO reference case sees light-duty vehicle (LDV) GHG emissions falling through the early 2040s, as a result of fuel economy improvements and greater deployment of electric vehicles (EVs), before increasing again through 2050 due to increased travel demand. The AEO projects U.S. passenger VMT to grow 23 percent between 2022 and 2050.[13]

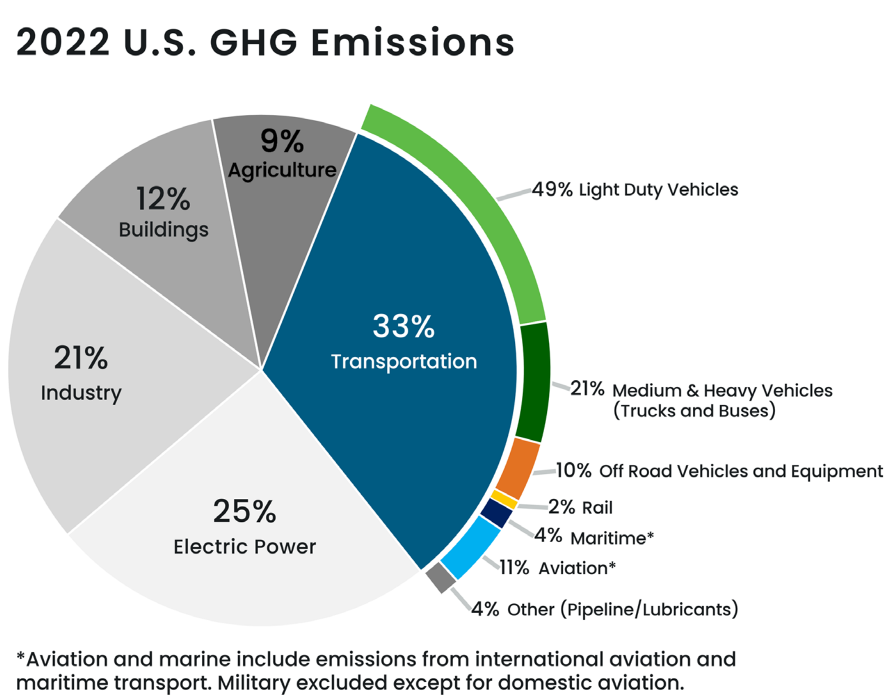


Figure 2: Total 2022 U.S. GHG emissions with transportation and mobile sources breakdown. Data derived from the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2022.

[a] This statistic includes emissions from transportation-related fossil fuel combustion, non-energy use (e.g., lubricants) sources, and hydrofluorocarbons from vehicle air conditioners and refrigerated trucks—as well as indirect emissions from electricity use.

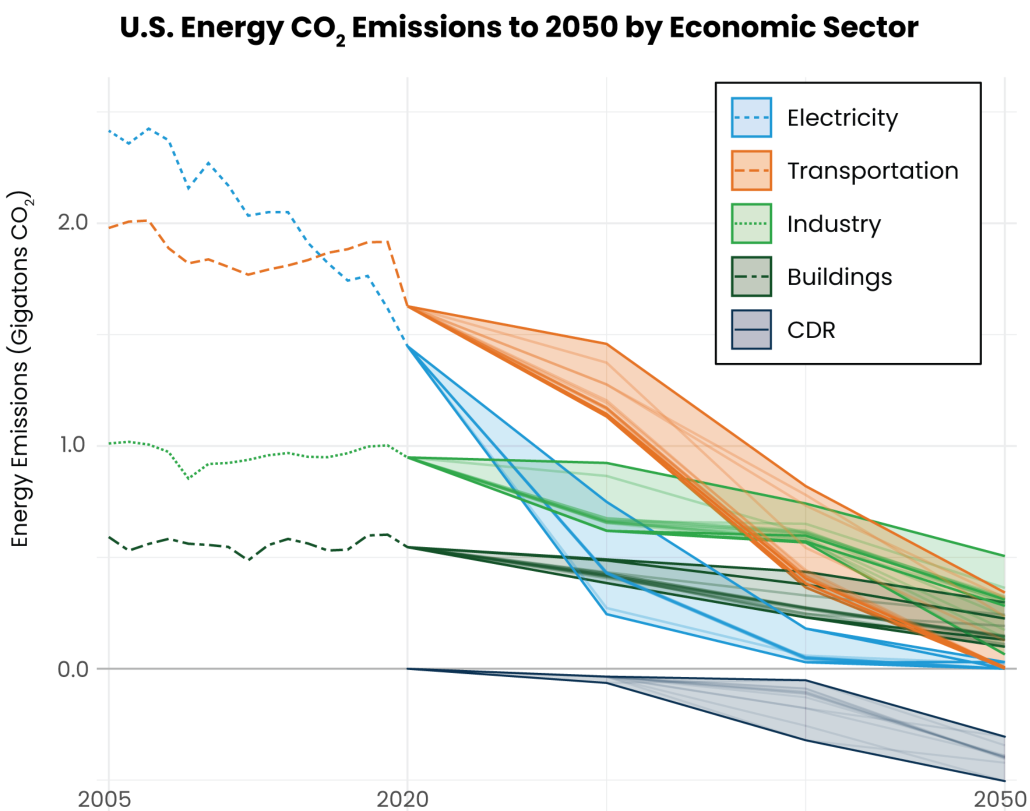


Figure 3: U.S. Energy CO_2 Emissions to 2050 by Economic Sector. Electricity CO_2 emissions and direct CO_2 emissions from the transportation, buildings, and industry fall dramatically in all scenarios, with the greatest reductions coming from electricity, followed by transportation, and non-land sink carbon dioxide removals (CDR) increase. Notes: Historical data are from EIA Monthly Energy Reviews, projections include data from all LTS scenarios using both GCAM and OP-NEMS, projections are shown in ten-year time steps. Source: [The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050](#).

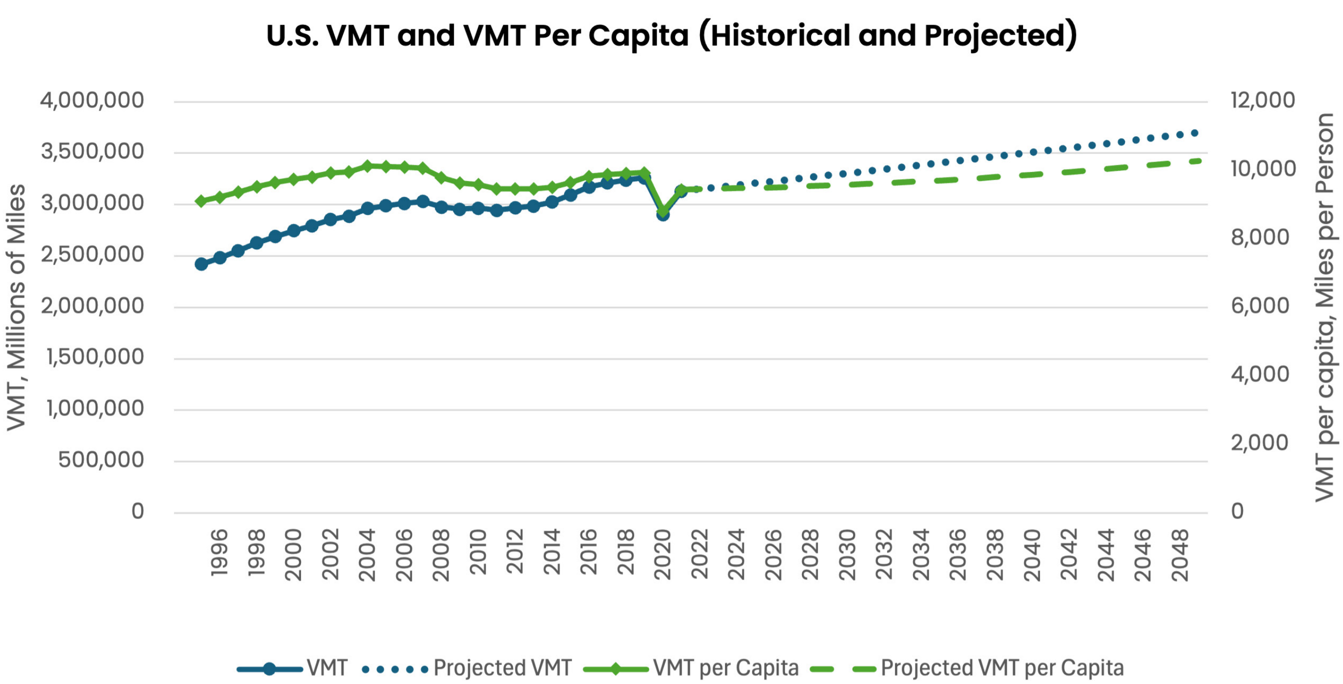


Figure 4: VMT and VMT per capita in the United States, historical 1995-2021 and projections 2022-2049. Sources: BTS and Census Bureau. Projections created using FHWA VMT Forecast [14] and Census Bureau population projection.[15]

In 2022, LDVs, including sedans and wagons, sports utility vehicles (SUVs), pickup trucks, and motorcycles, were responsible for the largest share of all U.S. transportation GHG emissions, 49 percent.

Medium- and heavy-duty vehicles (MHDVs) were the second-largest contributor to transportation sector GHG emissions in 2022, at 21 percent. This diverse category of vehicles includes freight trucks, larger pickup trucks, delivery and work vans, refuse collection vehicles, and buses.

Shifting trips to travel modes with lower carbon intensities per mile traveled can have a large impact on overall transportation sector GHG emissions. A Federal Railroad Administration (FRA) modal comparative analysis found that passenger travel by rail has substantially lower operational GHG emissions than single-occupancy vehicles or air.[16] Between 1980 and 2017, the fraction of commute travel in single-occupant vehicles increased from 64.4 percent to 76.4 percent, while the fraction using more efficient modes (carpools, transit, and walking) decreased.[17]

Freight emissions grew at five times the rate of passenger emissions in the United States between 1990 and 2021.[18] The growth in freight emissions has been primarily led by increases in emissions from freight trucking, which grew 83 percent during that same period primarily due to increased VMT (see Figure 5). Rail and marine GHG emissions per ton-mile are substantially lower than those from trucking.[19, 20] An analysis of rail and ocean-going vessels in California found that rail and maritime modes have life-cycle GHG emissions per ton mile that are 78 percent and 82 percent, respectively, below those of trucking.[21] However, approximately 73 percent of freight shipments in the United States are carried by trucks.[22] Increasing the share of freight transported by rail or maritime would require these modes to increase their speed, flexibility, service levels, or geographic reach. These factors are often why shippers choose to use less energy efficient modes, despite higher fuel costs. Strategies that can increase flexibility and choice of modes that are affordable and meet shipping requirements will be required to enable mode shifts.

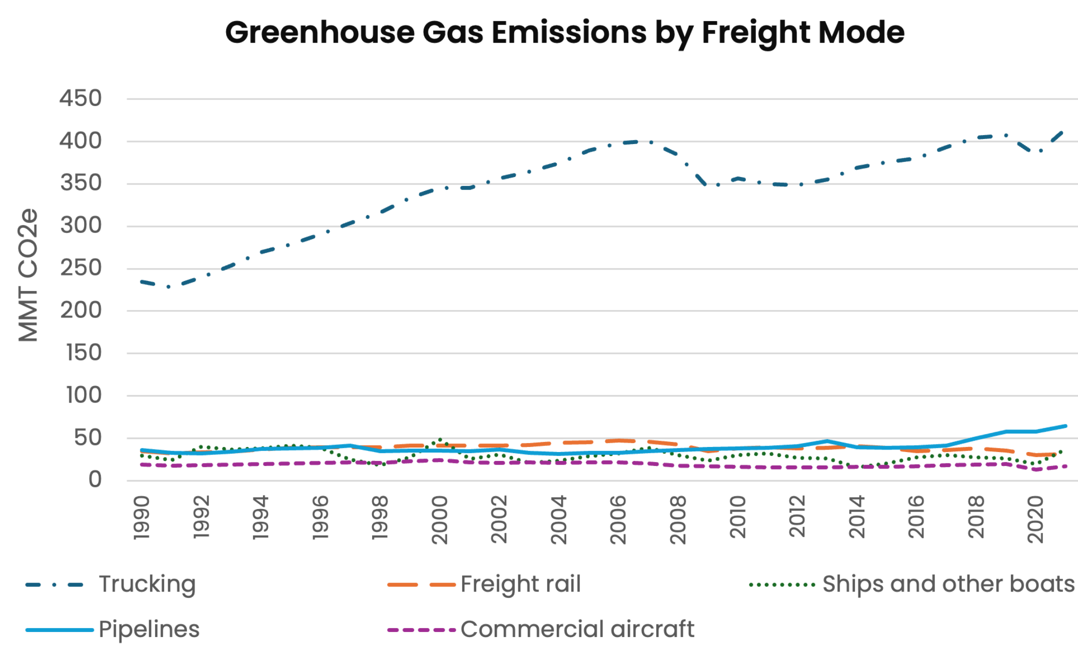


Figure 5: GHG emissions by mode of freight transport, 1990-2021. Data derived from the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks.

Average Carbon Dioxide Emissions per Passenger-Mile, by Mode of Transportation, 2019

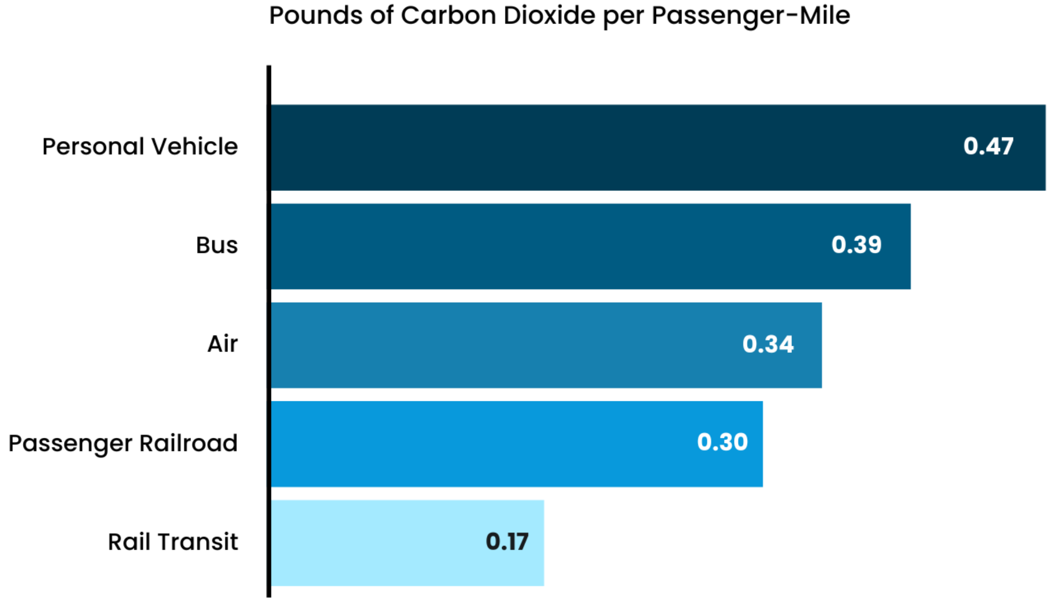


Figure 6a: Carbon dioxide emissions per passenger-mile from travel by personal vehicles are higher on a per-mile basis than emissions from other forms of passenger travel. Heavy- and light-rail transit produce relatively few emissions per passenger-mile. Source: Congressional Budget Office, Emissions of Carbon Dioxide in the Transportation Sector, 2022

Average Carbon Dioxide Emissions per Ton-Mile of Freight, by Mode of Transportation, 2019

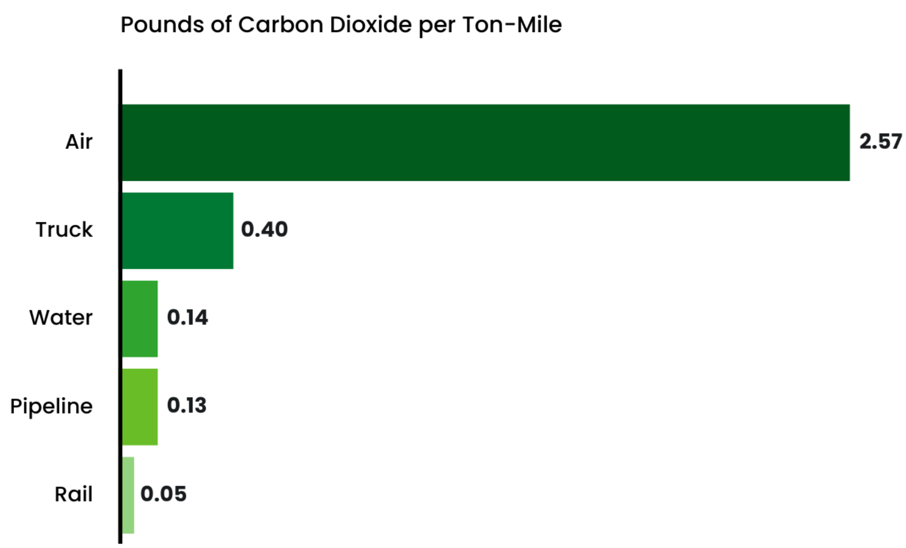


Figure 6b: Per ton-mile, emissions from trucking, the predominant mode of freight transportation, were eight times those from rail. And emissions per ton-mile from air cargo were six times those from trucks. Source: Congressional Budget Office, Emissions of Carbon Dioxide in the Transportation Sector, 2022.

While other modes can offer comparative advantages for shipping certain types of goods and certain types of trips, the American economy will continue to rely on trucks for the foreseeable future, with trucking tonnage predicted to increase by 35 percent by 2040.[23] In contrast, freight rail tonnage is projected to grow by 11 percent and domestic marine tonnage is projected to grow by 19 percent in the same timeframe.[24]

Although nationwide projections point to greater future demand for passenger and freight mobility across multiple modes[25, 26] and transportation GHG emissions remaining high, there is still the opportunity to help shape that future to reduce single-occupancy vehicle trips, increase mobility options and accessibility, improve quality of life, and reduce GHG emissions. Strategies like investing in transit and passenger rail and compact land use can put states on the path towards reducing VMT. Investing in intermodal transportation to allow freight to travel on more efficient modes such as rail and maritime for as long as feasible before relying on trucking can also reduce emissions. Leveraging these opportunities can influence future travel demand and contribute to a more sustainable transportation future.

2.2 Importance of the Efficiency Strategy

The projected growth in U.S. passenger VMT and freight goods movement represents a critical challenge to achieving decarbonization. All three strategies outlined in the Decarbonization Blueprint—increasing convenience, improving efficiency, and transitioning to clean options—will be key to meeting decarbonization goals and building a sustainable transportation sector. Investing in strategies to improve the convenience and efficiency of the transportation system is important to avoid a future in which increased driving and goods movement cancel out the GHG emissions benefits of improved fuel economy and electrification.

To meet its emission reduction goals, the United States needs a rapid and widespread transition to clean options, such as EVs, along with increased convenience to reduce overall travel demand. Efficiency strategies, such as increased fuel economy standards and encouraging mode switch, can ease these transitions. Transportation electricity demand can be lowered by deploying more efficient EVs that use less electrical energy per mile driven. Slowing or reversing VMT growth by giving Americans options to use more efficient modes, such as public transportation and rail, alleviates the demands on the electric grid necessary to power EVs. Convenience actions to encourage more dense and mixed-use land use development practices, transit-oriented development, and safe, accessible active transportation will in turn support travelers shifting from single-occupant personal vehicles to more efficient modes (see the Convenience Action Plan for more information on these strategies). A recent study found that electricity demand could be reduced by up to 800 TWh in 2050 by effectively implementing efficiency and convenience strategies.[27]

The Efficiency strategy is particularly critical to the freight sector as the transition to clean options such as battery- and hydrogen-powered trucks is expected to take longer in the face of additional challenges for moving heavy cargo over long distances.[28] Promoting more efficient options such as rail and maritime where feasible and implementing data-driven operational efficiency improvements can significantly reduce GHG emissions.[29]

Mode shifts to more efficient transportation options can reduce life-cycle emissions. Life-cycle emissions include the production and distribution of fuel, manufacture of vehicles, and construction and maintenance of transportation infrastructure. These emissions are typically accounted for in the industrial sector rather than in the transportation sector. However, reducing them is important for meeting economy-wide

GHG reduction targets. Reduced reliance on driving lowers the need for roadway construction and maintenance, upstream fuel cycle emissions, and vehicle cycle emissions. It can also reduce emissions of local air pollutants, such as nitrous oxides and particulate matter, and "non-exhaust" pollution from brake and tire wear, road wear, clutch wear, and road dust resuspension.[30] These types of emissions worsen air quality and are harmful to environmental and human health.

Carrying out actions within the Efficiency strategy yields multiple co-benefits:

- **Cost Savings:** Transportation is the second-largest household expense for low-income households, after housing.[31] Investments in public transit and vehicle efficiency can reduce transportation costs by reducing the need for car purchase, maintenance, fuel, and parking costs.
- **Economic Growth and Job Creation:** Investment in public transportation, rail, and active transportation infrastructure generates large economic returns. Every $1 invested in public transportation generates an estimated $5 in long-term annual economic returns, and every $1 billion invested in public transportation supports about 20,000 jobs.[32]
- **Air Quality and Health**: Reducing the number of emissions-emitting vehicles on the road (especially in densely populated areas) will also decrease air pollutants that are harmful to human health. The particle emissions from tires and brakes are another major source of pollution associated with driving—in both electric and internal combustion engine vehicles.[33] Pollution from tailpipe and non-tailpipe emissions contribute to health inequities for communities,[34] especially communities of color, which are disproportionately located near major roadways.[35, 36, 37]
- **Accessibility and Community:** Mobility options increase access to job opportunities, education, and everyday destinations for those who cannot or do not drive, especially older individuals, people with disabilities, youth, and people living in lower-income communities. For seniors, lack of transportation is the most common reason for not leaving the home, limiting access to basic services.[38] In contrast, both active and public transportation are linked to decreased loneliness, increased access to family and friends, and greater levels of socialization en route as compared to driving alone.[39, 40]

In incentivizing these more efficient options, federal agencies and state and local governments should consider equity implications and work with affected communities to ensure these policies improve environmental quality and roadway safety, and meet the transportation needs of underserved, overburdened, and disadvantaged communities.

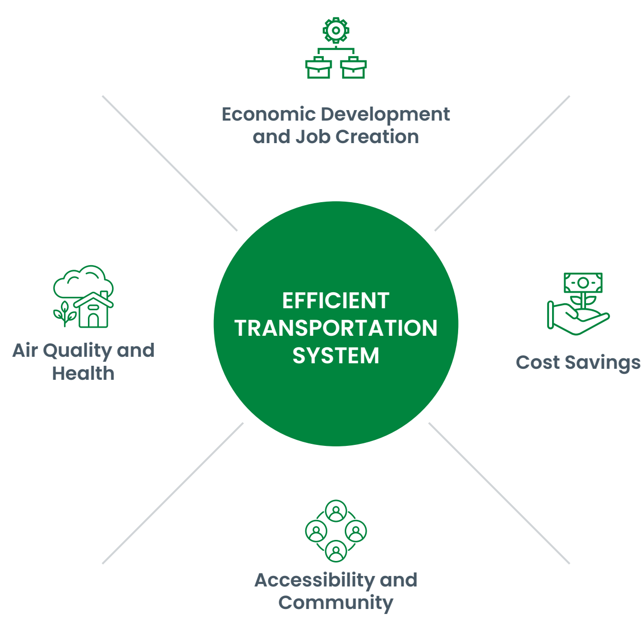


Figure 7: In addition to emissions reduction, an efficient transportation system has multiple co-benefits.

3. EFFICIENCY ACTIONS

This section describes key Efficiency actions to significantly reduce GHG emissions from the transportation sector. For each action, the action plan discusses existing federal programs, future-looking opportunities to reduce GHG emissions, and example actions and best practices that state, territorial, Tribal, regional, local, and industry stakeholders have taken.

3.1 Public Transportation

The United States is highly dependent on energy-intensive travel modes. In 2022, 87 percent of all trips were made in private vehicles. Among commuters, 91 percent drove alone.[41] Strategic investments in public transit infrastructure and services can provide more options for low-carbon passenger travel. Investments in active transportation, including walking, biking, rolling[b], or using personal and shared e-mobility devices, can also provide the public with more options for low- and no-carbon travel. Strategies related to active transportation are described in the Convenience Action Plan.

Public transit investment is one of the most effective means to reduce transportation sector emissions. According to a Transit Cooperative Research Program report of the Transportation Research Board, "[p]ublic transit in the U.S. saved 63 million metric tons of carbon dioxide equivalent emissions in 2018—the equivalent of taking 16 coal power plants offline for a year." Boosting public transit ridership can directly reduce GHG emissions by displacing trips in single-occupancy vehicles. Furthermore, transit moves people more efficiently in the same amount of road space than single-occupancy vehicles: private vehicles can move 600-1,600 people per hour in one lane, while a dedicated bus lane can move 4,000-8,000 people per hour, and rail can move 10,000-25,000 people per hour,[42] meaning transit can reduce overall congestion and the GHG emission associated with building and maintaining road infrastructure (see Figure 8).

Transit investments also indirectly reduce GHG emissions by enabling compact, mixed-use development in urban, suburban, and rural contexts and by improving access to local and regional destinations. These indirect effects of transit funding are more difficult to measure, but they are potentially just as impactful or even more so than the direct effects in the long run.

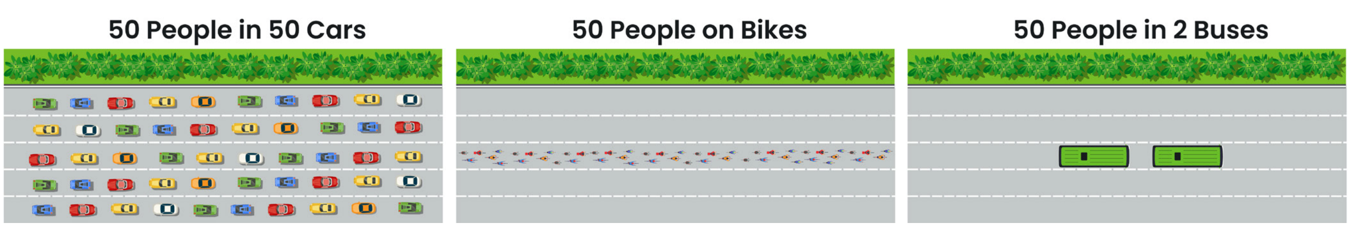


Figure 8: Modes like transit and biking can carry the same number of people in significantly less space than single-occupancy vehicles.

[b] As used above, "rolling" indicates the variety of devices individuals may use as part of active mobility/transportation. The term includes manual or power wheelchairs, walkers, strollers, scooters, roller-skates/blades, and other non-vehicular methods of transportation with wheels.

Chicago's transit systems in operation.

Decarbonization strategies that reduce VMT through smart land use and growth, such as transit-oriented development, integrated land use and transportation planning, and designing walkable communities, are discussed in greater detail within the Convenience Action Plan.

Development-oriented transit, or extending transit to high density but transit-poor neighborhoods, can also reduce VMT by providing new transit options to compact areas that are well suited to support transit services. The Convenience Action Plan also covers prioritizing fixing existing assets rather than expanding roadway infrastructure, which can create space for active and public transportation while benefitting communities.

Transit systems serve urban, suburban, and rural communities alike, and high-quality, efficient transit looks different in these different environments. For example, a large bus following a fixed route may transport hundreds of riders at once in an urban area, but in a rural area, the same bus may only transport two riders at once, making it an inefficient service. Rural areas may benefit from microtransit, a demand-responsive service that uses flexible routes and smaller, more efficient vehicles than conventional transit. Microtransit can also expand transit access within suburban and urban areas by connecting underserved areas to conventional transit services. Rightsizing transit investments is an important step to ensure they increase efficiency and best serve the needs of riders given the local context.

Investments in public transit also support a thriving economy and promote equitable access to work, school, and social services. A DOE study found that, without any transit in Chicago, travel speeds would drop by 13 percent in the city and 5 percent in the region, and up to 20 percent of all non-work activities would be canceled. These impacts would result in $12 billion of economic losses, fourteen times the hypothetical savings from eliminating transit service.[43] Over 71 percent of transit riders are people of color or low-income[c], so investments in transit also promote equitable transportation. Transit is of great importance to those who are unable to afford automobiles or have physical conditions preventing them from driving, including those in rural areas. Additionally, transit investments have the potential to improve overall safety because passenger transportation by transit is significantly safer than transportation in personal vehicles: an FTA analysis found that the number of fatalities per VMT in personal automobiles is more than three times that of buses, and more than twice that of heavy rail. Because transit vehicles have a much higher average occupancy than personal vehicles, the safety benefit of transit is even greater.[44, 45]

Research on multiple cities demonstrates the importance of transit investments. For example, a McGill University study found that significant cuts in bus service caused ridership decreases from 2011 to 2015 in the 25 largest metro areas in the United States and Canada, even as the economy grew.[46] In contrast, the Greater Richmond Transit Company's policy of maintaining and expanding service during COVID-19 and continuing to offer free fares has likely contributed to their success in growing ridership.[47] DOE simulations using agent-based modeling have also found that transit investments boost ridership. One DOE study found that budget increases of 30 to 40 percent could improve ridership by 11 to 20 percent in Chicago through optimizing transit schedules to meet rider demand.[48, 49] A preliminary simulation in Chicago found that increasing the speed of one-third of bus routes by 5 percent would increase ridership by 7 percent, and increasing speed by 30 percent would increase ridership by 11 percent. Another found that six specific transit projects in the San Francisco Bay area—which include line extensions, increased service frequency, and increased speed—in the short run had little impact on overall regional transit ridership, but did shift up to 10 percent of new transit riders from personal and ridehail vehicles and improved mobility (travel distances, speeds, and times) for existing transit riders. These types of projects likely have larger benefits over the long run, when travelers can change their home or work location in response to improved transit service.[50]

Similar to transit, intercity bus service also provides important mobility and has lower GHG per passenger mile than driving. Carpooling and vanpooling can also reduce trips in single-occupancy vehicles, leading to more efficient travel. Sharing rides—including car/vanpooling and shared ridehailing trips—reduces the emissions per passenger mile traveled. However, research indicates that reduced energy use from pooling can be offset by increased energy use from deadheading (the distance traveled without a passenger) and riders shifting from more efficient modes (such as transit, biking, and walking).[51, 52]

FEDERAL ACTIONS AND INITIATIVES

Capital Investment Grants (CIG). The FTA's CIG program funds large transit capital investments including new and expanded rapid rail, commuter rail, light rail, streetcars, and bus rapid transit. CIG makes transit more widely available, giving more Americans a low carbon transportation option. BIL provided the program $1.6 billion per year in advance appropriations for fiscal years (FY) 2022-2026 and authorized $3 billion per year in annual appropriations over the same time period, for a total of $4.6 billion per year.

[c] In 2021, 71 percent of transit riders nationally are either members of a racial or ethnic minority, are Hispanic white, or are non-Hispanic white with a household income of less than $25,000 according to the National Household Travel Survey.

FTA discretionary grant programs. FTA administers many competitive grant programs in addition to CIG. These programs fund planning, capital projects, operational expenses, and other activities such as workforce development, transit research, and transit-oriented development planning. Several provide pilot funding to allow transit agencies to test innovative technology and business practices, such as the Safety Research and Demonstration Program. Others fund major projects that would be difficult to fund with only formula funding, such as the Grants for Buses and Bus Facilities Program and the Rail Vehicle Replacement Grants. Competitive grants such as the Tribal Transit Competitive Program seek to advance equity goals. These programs also support USDOT priority areas such as innovation, workforce development, and safety. Other USDOT competitive grant programs, such as the Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program and the Reconnecting Communities and Neighborhoods program, have a multimodal focus and can be used to improve transit service and access. FTA's support for transit-oriented development is covered in more detail in the Convenience Action Plan.

FTA formula grant programs. FTA maintains several formula grant programs, many of which BIL reauthorized or expanded. These grants guarantee funding for specific groups, such as urban and rural localities, metropolitan planning organizations (MPOs), and rural transit providers. Other programs are specific to fleet and organization maintenance, such as the Bus and Bus Facilities and State of Good Repair (SGR) programs. The increased funding through BIL is essential to supporting decarbonization efforts through encouraging mode shift and can have other environmentally beneficial effects including compact development, decreased car dependency, improved walkability, and lower overall energy consumption.

Transfer highway funds to transit. Many FHWA programs allow recipients to spend funds on public transportation and bicycle and pedestrian improvements. However, some state DOTs, territories, cities, and Tribes may not easily be able to make use of FHWA funding for public transportation projects due to processes and requirements that are more suitable to large-scale highway projects. Recipients of certain FHWA formula programs can transfer or "flex" funds from FHWA to be administered by FTA for public transit projects. Flexing funds to FTA programs facilitates federal investments in public transportation at the local level. Between FY 2018 and FY 2022, a total of $8 billion in flexible funding was transferred to FTA for transit projects.

Reduced fares for seniors, people with disabilities, and Medicare cardholders. Under 49 U.S.C. Section 5307, federally subsidized transit providers may not charge more than half of the peak fare for fixed route transit during off-peak hours for seniors, people with disabilities, and Medicare cardholders. This provision increases access to transit for these major swaths of the population, while also assisting some of the people who are most likely to benefit from reduced financial burden to use transit. Evidence on the effect of such programs on emissions and vehicle miles traveled in the United States is limited. A study on a free local bus pass for riders over 60 in England found that eligible riders largely took bus trips that would not have otherwise been taken, with little substitution for trips on other modes. In contrast, studies on a fare-free subway program in Seoul found that the program promoted mode shift from personal vehicles to the subway[53] and reduced vehicle ownership among seniors.[54]

DOE Energy Efficient Mobility Systems (EEMS) Research and Development Funding. DOE periodically announces funding opportunities for innovative mobility-system level approaches to improve the efficiency and convenience of public transportation and demonstrates these approaches in pilots. Funded research projects have investigated approaches to improve the efficiency and effectiveness of the transit bus system, including the transition to electric buses.[55] Other work looked across modes, such as commuter rail, shuttle bus, subway, and new mobility services to optimize planning and operations of the transit system to improve multimodal transit trips. This portfolio of work includes redesigning fixed-line services, extending microtransit operations, and deploying autonomous vehicles and shared mobility options in conjunction with innovative business models to show the potential to make environmentally sustainable public transit an appealing alternative to private vehicle use. Another research effort focuses on optimizing automated electric feeder vehicles that will actively coordinate with fixed-route transit and signal infrastructure to accommodate user-specific travel needs.

DOE National Impacts Project. DOE has funded the development of a National Impacts project that aims to provide high-fidelity transportation modeling to communities throughout the country by linking three existing transportation modeling approaches developed by DOE National Labs. The project will provide insights into the effectiveness of decarbonization strategies such as transit investments at the county level and then scale up results to the national level using different urban typologies.

Funding for transit operations during the COVID-19 pandemic. During the COVID-19 pandemic, Congress recognized the need to support transit agencies. Three different laws provided pandemic-era transit funding: the Coronavirus Aid, Relief, and Economic Security (CARES) Act, the Coronavirus Response and Relief Supplemental Appropriations Act of 2021 (CRRSAA), and the American Rescue Plan Act of 2021 (ARP). FTA allocated $25 billion of CARES Act funding to recipients of urbanized area and rural area formula funds, with $22.7 billion to large and small urban areas and $2.2 billion to rural areas. Funding was provided at a 100-percent federal share, with no local match required, to support capital, operating, and other expenses generally eligible under those programs to prevent, prepare for, and respond to COVID-19. The federal government provided operating expenses to maintain transit services as well as pay for administrative leave for transit personnel due to reduced operations during an emergency. CRRSA provided $14 billion in supplemental funding to support the transit industry at a 100 percent federal share, with $13.26 billion allocated to urban areas and $678.2 million allocated to rural areas. ARP provided a further $30.5 billion for transit, with $26.6 billion allocated to rural and urban areas, $2.2 billion provided to FTA grant recipients in communities that demonstrated additional pandemic-associated needs, and $1.675 billion for CIG projects.

FTA ferry programs. FTA administers several grant programs that provide funding for ferry transit services. The Passenger Ferry Grant Program provides competitive funding for passenger ferries in urban areas. The program aims to upgrade aging infrastructure, improve reliability, enhance project readiness, and provide connectivity to other modes of transportation, including bicycle and transit connections. In 2023, FTA announced over $50 million in awards to seven projects in four states under the Passenger Ferry Program. The Ferry Service for Rural Communities Program, established in BIL, provides $200 million per year through FY 2026 in competitive funding for essential ferry services in rural areas. In 2023, FTA awarded $170 million to six projects in four states and American Samoa.

Complete Trip ITS4US Deployment Program. This $40 million USDOT initiative enables communities to demonstrate integrated technology deployments that support independent and seamless travel for all users across all modes, regardless of location, income, or disability. The program is centered around the concept of complete trips (i.e., an individual’s ability to travel from origin to destination without using a personal vehicle and without encountering gaps in the travel chain). The program funds multiple, large-scale replicable deployments in a three-phased approach, from concept development to design and testing to operations and evaluation.

Following the operations phase, the deployment sites must operate and maintain the deployed system for a minimum of five years.

National mode shift target. USDOT's Strategic Plan for 2022-2026 sets a national mode shift target: increase the percentage of person trips by transit and active transportation modes from roughly 4 percent in 2020 to 6 percent.[56] FHWA, FTA, and FRA will collaborate on achieving this target through research and initiatives that promote safe public and active transportation infrastructure.

Green building certifications. Many HUD programs have minimum energy standards or requirements in the form of green building certifications. For grantees and contractors receiving funding from HUD, these green building certifications encourage active and public transportation along with compact urban design. For example, projects under the Enterprise Green Communities Program must include transit access for any new, urban construction projects—with higher scores given to projects that prioritize transportation connectivity, provide free transit passes to residents, and post maps to the nearest transit stops in common areas in the building.

OPPORTUNITIES

Continued investments for transit systems. The CARES Act, CRRSAA, ARP, and BIL provided much-needed investment into the nation's public transit systems, which will significantly improve the reach, reliability, and quality of transit service. Despite these investments, transit systems have not fully recovered from the pandemic. Nationwide transit ridership is still 21 percent below its pre-pandemic level. Ridership continues to grow, and there are other signs of recovery: metro areas with fewer than 500,000 residents have seen faster growth in ridership and are only 13 percent below pre-pandemic levels, and several metro areas, including Richmond, VA, Tucson, AZ, and Spokane, WA, have surpassed pre-pandemic ridership levels.[57] Although riders are returning to transit, many transit agencies nationwide are facing a "fiscal cliff." Transit agencies have faced decreases in fare revenue, forcing many agencies to consider service reductions. Cutting service leads to lower ridership and even lower fare revenue. As a result, transit agencies are in need of additional funding to serve current and future riders and reverse revenue losses.[58] For example, the Massachusetts Bay Transportation Authority is facing a deficit of $400 million, while the Washington Metropolitan Area Transit Authority (WMATA) is facing a $700 million shortfall which, without additional funding, would require a 67 percent reduction in service.[59]

Transit agencies need short-term assistance and continued support to avoid the upcoming fiscal cliff and to enter a virtuous cycle of revenue increases. Continued investment is necessary to maintain public transit's current emission reduction benefits and to realize future reductions. Funding for operations is especially needed, as most FTA funding is for capital projects and transit agencies generally cannot use capital funding to cover operational shortfalls.

Focus resources on strategic transit investments. Directing transit funding towards areas where public transportation demand exceeds the supply of public transportation service would help to address gaps, particularly in underserved areas. New service in transit deserts can most effectively serve users and reduce emissions by providing transit service and mobility hubs that are appropriate to the community context, including new viable transit models in suburbs with shifting demographics. To help agencies prioritize new service, DOE has developed agent-based models that simulate the effects of increasing service frequency, reducing delays, and adding or modifying routes.

Expand the frequency and hours of transit service. Providing increased transit service at different times of day can encourage more people to use transit rather than driving alone. For example, transit agencies can pilot providing increased nighttime, weekend, and off-peak service. A 2016 study found that service frequency and travel time were the two most important factors when riders decide between taking a trip on transit or on another mode.[60] Expanding off-peak service (late-night and early-morning service) can also promote transit usage for both non-commuter trips and service worker commuting trips requiring later and earlier hours. Off-peak ridership has proven more resilient to the post-COVID-19 ridership decline, largely because late-night and early-morning jobs tend not to allow for remote work and workers with these jobs tend to be more transit-dependent.[61] A pilot of late-night bus service in Athens, Greece, found that most new riders would have otherwise used their personal automobiles for the trip[62].

Encourage use of flex funding to expand available funds for transit projects. While more transit funding is needed to expand and improve transit service, some agencies may not know about existing funding sources available to them. For example, utilization of the authority to transfer funds from certain FHWA formula programs to be administered by FTA for public transit projects varies significantly from state to state. Between 2007 and 2011, four states transferred more than 25 percent of their flexible funding to FTA for transit projects, while 16 states transferred less than 2 percent.[63] Increased attention to the flexibilities among transit agencies and states could lead to a greater utilization and impact of the flex funding program and help funding recipients implement transit and transit access projects. To promote the use of flex funding, FTA is developing communication materials such as a website, brochures, webinars, and case studies.

Provide knowledge sharing and capacity building around fare discount programs. Many transit agencies have implemented reduced or free fare programs. Seventeen of the nation's 50 largest transit agencies provide reduced fares for low-income riders. These programs are largely intended to reduce the burden of transportation costs for low-income riders, who make up 37 percent of transit riders, and often have to make difficult decisions between food, housing, personal care, and transit.[64] Agencies were able to use pandemic relief funds from the CARES Act, and CRRSAA for operational expenses, including for free and reduced fare programs. Agencies that implement free and reduced fare policies may see short- and long-term ridership increases, increased rider satisfaction, and faster ridership recovery following the pandemic compared to other agencies.[65] However, agencies that implement free or reduced fares may need to identify funding sources to replace lost farebox revenue to ensure they are able to provide the same level of service. Through regional collaboration and direct input from communities, transit agencies may be able to adopt new fare policy structures that contribute to rider accessibility and improved equity outcomes, which simultaneously work towards modal shift and decarbonization goals more broadly. Agencies can be further assisted through knowledge sharing and capacity building. The federal government can support this through funding pilot studies, organizing peer exchanges, and researching and publishing best practices and lessons learned from free and reduced fare programs.

Support research and implementation of Mobility Payment Integration (MPI) and Open Loop Payment Systems. USDOT and other federal agencies can further support the development and implementation of MPI systems, which are a suite of advances in fare collection technology that work to make it easier for users to pay for multiple modes of transportation.[66] MPI can improve customers' experience with public transit and facilitate the use of shared micromobility, microtransit, and other innovative first-mile/last-mile solutions to access transit.[67] Open loop payment systems allow riders to pay directly with a credit/debit card or mobile device instead of using a ticket or card. Payment can be made at the turnstile, onboard a vehicle, or after completing the trip or all trips taken in a day. Open loop payment systems can enable easier access to transit systems, particularly for riders who choose to use transit instead of other modes available to them.

Improve transit stops. Many transit stops lack amenities such as seating, lighting, shelter, wayfinding, and real-time signage. Investing in transit stop improvements can make transit more attractive to potential riders and more accessible to riders with mobility impairments.

Set passenger mode shift targets. USDOT could set mode shift goals beyond 2026, out to 2030 and beyond. USDOT could also support states, territories, and localities implementing mode shift targets by showcasing successful examples of where mode shift targets were achieved and furthering the use of empirically proven and tested strategies to achieve longer-term decarbonization goals.

Improve first-mile/last-mile connections to transit. Often, a barrier to transit use is the time and distance to reach a transit stop. Improving choices to reach transit stops, known as first-mile/last-mile (FMLM) connections, can help to increase transit ridership. The federal government, transit agencies, and private industry can expand transit access and improve riders' experience by investing in first- and last-mile infrastructure that allows riders to walk, bike, roll, or otherwise reach a transit stop. This could include siting bikeshare stations near transit, expanding sidewalks and bike lanes near transit so people can walk or bike to access it, or coordinating schedules across modes to reduce wait times for people transferring from rail to bus, for example. A DOE study in Chicago found that subsidizing ridehail services as FMLM connections can increase transit boardings by eight percent for a 10 percent increase in spending.[68]

Programs for carpooling and vanpooling. Programs that incentivize carpooling and vanpooling, such as preferential parking or lower tolls, can encourage more people to choose these shared rides rather than opting to travel alone in a personal vehicle. Employers or transit agencies can also facilitate ride sharing by matching drivers with riders for trips, for example.[69]

Transit network redesigns. Network redesigns involve planning and implementing significant changes to a transit agency's service networks by evaluating how the network structure as a whole meets the agency's goals and serves its riders. Redesigns can help to improve the quality of transit service by responding to current and emerging travel patterns and the needs of current and potential riders, which can boost ridership. They can also mitigate operating costs: many are planned as cost-neutral projects to optimize the agency's resources across its network. Most redesigns combine capital improvements, such as dedicated bus lanes, with operating changes such as transit signal priority, improved stop spacing, adjusting frequency, and headway-based scheduling.[70]

Research on mode shift and efficiency. The federal government plays an important role in funding and guiding research and technology development. While research and development activities do not by themselves directly reduce GHG emissions, they are critical enablers of future change. Federal agencies, including the USDOT's Office of the Assistant Secretary for Research and Technology, DOE's EEMS team, DOE's National Labs, and EPA, are actively engaged in research on transportation mode shift. Federal agencies can provide further funding, coordination, and guidance for research on the following topics:

- Mode shift effects of different types of infrastructure projects and service improvements
- Benefits of mode shift from infrastructure investments and changes in relative pricing
- Strategies to encourage passenger and freight travel on efficient, sustainable travel modes
- GHG reduction potential of emerging modes, and how to encourage efficiency
- Changes in travel behavior as a result of the COVID pandemic and remote work

- GHG effects of emerging mobility services such as pooled ridehail and microtransit
- Comparisons of the effectiveness of policies in different regional contexts around the country

Future research can leverage agent-based transportation system simulation and modeling capabilities, including those maintained by DOE. Research into these areas is needed to help agencies invest strategically in improvements to transit, rail, maritime, and multimodal infrastructure, and to develop accurate estimates for the decarbonization benefits of these strategies, and to craft policy to support and incentivize mode shift.

STATE, LOCAL, AND INDUSTRY EXAMPLES

Chicago, IL: Pace Suburban Bus. Pace Suburban Bus operates the Pulse Bus Rapid Transit (BRT) system in Chicago's suburban areas, where traffic congestion can be a significant challenge. To address this, the system incorporates features like Transit Signal Priority (TSP) and curb extensions to improve service reliability and efficiency. Additionally, on highways like I-55, buses utilize bus-on-shoulder (BOS) operations to bypass traffic congestion, ensuring smoother and more reliable service. These measures have led to significant performance improvements. On the Pulse Milwaukee route, on-time performance increased from around 65 to 92 percent with BOS operation on I-55, and corridor bus ridership increased by 50 percent compared to levels before the COVID-19 pandemic.

MBTA's Early Morning and Late-Night Bus Service Pilots. The Massachusetts Bay Transportation Authority (MBTA) conducted two pilot programs in 2018 to provide late night and early morning bus service. In April 2018, MBTA started service before 5 a.m., seven days a week, on Boston's busiest bus routes. In April 2019, early morning service was made permanent. In September 2018, MBTA expanded bus service from 10 p.m. onward with additional trips, later scheduling, and route variations to include areas where night service was most needed. In September 2019, some of these changes were made permanent.

MARTA's new fare system. The Metropolitan Atlanta Rapid Transit Authority (MARTA) is developing a new automated fare collection system that will improve rider experience in several ways. An open payments system will allow customers to pay fares using a debit card, credit card, mobile wallet, or Breeze Card. Modernized bus fare boxes with digital screens and improved software will speed up the boarding process. The fare payment system will also expand to all transit modes, including bus, rail, MARTA Rapid, and the Atlanta Streetcar, which currently has its own payment system. The open-architecture design will allow other transit agencies in the region and third-party trip-planning apps to integrate with MARTA's system. It will also allow MARTA to offer flexible fares for employer programs, senior or student discounts, and special events and promotions. The upgrades are expected to benefit MARTA by increasing farebox recovery.[71]

Washington, D.C.: Bus Priority Toolbox. The District Department of Transportation (DDOT) has developed a set of potential bus priority treatments that can be applied to a wide variety of road projects. The treatments are grouped into five categories:

- Bus operations strategies: treatments related to stop placement and route design that can improve bus speed and reliability by reducing dwell time at stops and bunching. These strategies are typically led by the transit agency.
- Traffic control strategies: changes to signal timing and traffic patterns can favor bus operations and improve bus service. These strategies are usually controlled by DDOT.
- Bus stop infrastructure strategies: physical improvements at bus stops can improve reliability by ensuring that buses are not blocked from entering or exiting the stop.

- Bus lane strategies: dedicated bus lanes, and measures that improve bus lane compliance, can help buses maintain speed and reliability in congested streets.
- Bike and bus strategies: treatments that help safely accommodate buses and cyclists in the same corridor help to promote both modes.

Bus improvements often involve multiple agencies, such as infrastructure owners like DDOT and transit operators. The Toolbox helps to improve coordination between agencies and ensure that they identify opportunities to improve bus service in their other projects. WMATA is in the process of finalizing its Better Bus Plan, the first redesign of the Metrobus network since its creation in 1973. The goal of the redesign is to keep up with a changing region, better connect riders with where they need to go, promote equity, inclusiveness, and access to opportunity, and create a network that is easy to use no matter where you are. The plan includes bus priority upgrades that are in alignment with the Bus Priority Toolbox, including dedicated bus lanes, enforcement of bus planes, transit signal priority and queue jumps, and all-door boarding.[72] The proposed 2025 Better Bus Network was released in May 2024 and is currently open to public comment. Based on public input, the plan will be finalized in Fall 2024 and implemented in Summer 2025.[73]

Oregon Department of Transportation's Climate Strategy. In 2022, Oregon's Land Conservation and Development Commission updated the state's transportation planning rules to align with Oregon's Sustainable Transportation Strategy (STS), which outlines how the transportation sector will contribute to Oregon's overall goal of an 80 percent reduction below 1990 emission levels by 2050. The STS sets objectives related to electrification, mode shift, transportation demand management, and road pricing, among other strategies, to reach the transportation sector's 2050 emissions goal of a 75 percent reduction. In response, Oregon DOT staff identified three decision points in the Statewide Transportation Improvement Plan (STIP) to drive GHG emissions reductions. After a three-phased review of the 2021-2024 STIP, Oregon DOT produced a draft STIP for 2024-2027 that reduces investments that challenge the emissions goal, such as new highway lane-miles, and increases funding for public and active transportation by nearly $100 million.[74]

Rural North Carolina's Rural Transit Expansion. In 2018, Greenway Public Transportation, a transit provider for the Western Piedmont Regional Transit Authority in rural Conover, North Carolina, launched new flex service routes after securing grant funding. The routes aimed to serve low-income and underserved communities and featured a free promotional service period while riders learned about the new routes. Compared to the previous year, Greenway saw a ridership increase of almost 70 percent in 2019 and found the new service was especially useful for connecting riders to a health facility.

Bastrop, TX: Low-Speed Electric Vehicle (LSEV) on-demand mobility service. Between December 2020 and November 2022, the City of Bastrop, a rural community in central Texas, piloted a free, on-demand shared mobility service in its downtown area with funding from DOE. Passengers could request a ride through an app, by calling or texting the driver, or by hailing the vehicle from the street. During the pilot period, the service provided almost 15,000 trips. Approximately 27 percent of rides had more than one passenger, and 2,026 trips served passengers with mobility challenges. In a passenger survey and a follow-up community survey, 33 percent of respondents reported that they would have driven alone if the service was not available.[75]

ACTION AGENDA

The following represent a selection of promising opportunities for reducing emissions through investments in public transit. The table below summarizes these actions and associated lead sectors.

Private Sector	• Improve first-mile/last-mile connections to transit. • Scale up production of transit vehicles. • Offer employer transit subsidies. • Develop and expand transit apps and data tools.
Tribal, State, Regional, and Local Governments, including Transit Agencies	• Expand and improve public transportation service. This includes increasing availability, frequency, speed, reliability, efficiency, and comfort. • Improve first-mile/last-mile connections to transit. • Use flex funding to expand available funds for transit projects. • Order base model buses for transit fleets without over-customization or use joint procurement with a shared technical specification.
Federal Government	• Implement Federal Transit Administration and multimodal grant programs. • Include provisions to encourage access to transit in green building certifications.
Research	• Research mode shift effects of strategies to improve and expand public transportation.

3.2 Intercity Passenger Rail Transportation

Intercity rail transportation is generally less carbon-intensive than air or single-occupancy car travel on a passenger-mile basis. System-wide, travel on the National Railroad Passenger Corporation (Amtrak) network is approximately 33 percent more energy-efficient than air travel and 57 percent more energy-efficient than travel in single-occupancy vehicles,[76] which translates to an emissions savings of up to 83 percent compared to driving and 72 percent compared to flying.[77] The emissions savings are even greater on the electrified portion of Amtrak's network in the Northeast,[78] which accounts for 2.1 percent of track-miles in Amtrak's network[79] but 32.2 percent of customer trips. For example, an Amtrak trip from Los Angeles to San Diego, where diesel trains are used, produces 50 percent fewer emissions than the same trip by car and 55 percent fewer than the same trip by air. An Amtrak trip from Boston to New York City on the electrified Northeast Corridor offers even greater emissions benefits, producing 82 percent fewer emissions than traveling by car or air.[80] Shifting trips from less efficient modes to passenger rail can help reduce emissions from passenger travel. To do so, investments to make passenger rail faster, more reliable, and more extensive will allow passenger rail to be more competitive with air and personal vehicles for intercity travel. In addition, passenger rail provides needed intercity access to many rural communities that lack other options such as nearby airports.

FEDERAL ACTIONS AND INITIATIVES

Corridor Identification and Development Program (Corridor ID). This FRA discretionary grant program funds planning and development for intercity passenger rail corridors. In Step 1 of Corridor ID, grantees receive funding to develop a scope, schedule, and cost estimate for a service development plan. In Steps 2 and 3, grantees can receive additional funding to complete service development planning, preliminary engineering, and environmental review. The goal of the program is to produce a pipeline of intercity rail passenger projects ready for implementation with funding under the Federal-State Partnership for Intercity Passenger Rail Grant Program (see below). Such projects will make intercity rail travel a more viable alternative to higher-emissions modes of travel.

Federal-State Partnership for Intercity Passenger Rail Grant Program. This program provides tens of billions of dollars for capital projects that reduce the state of good repair backlog, improve performance, or establish new intercity passenger rail service. The program was authorized by BIL in 2021, providing funding for new intercity passenger rail service at levels not seen since the creation of Amtrak in 1970. Funded projects will expand passenger rail service and improve existing corridors, making it more competitive with higher-emissions modes of travel.

Restoration & Enhancement (R&E) Program. This FRA discretionary grant program provides operating assistance grants to initiate, restore, or enhance intercity passenger rail services. The goal of the program is to provide multiple years of operating assistance so that service sponsors can establish new or expanded services, add frequency to existing services, or offer new on-board services that will make intercity rail travel a more viable alternative to higher-emissions modes of travel such as planes and personal vehicles.

Federal grants to Amtrak. FRA administers federal funds appropriated by Congress to Amtrak through two grant agreements: one for the Northeast Corridor from Virginia to

Brightline: high-speed intercity passenger rail service in Florida.

Massachusetts, and one for the national network. Amtrak uses the funds for operating expenses, capital maintenance of fleet and infrastructure, capital expansion and investment programs, and capital debt repayment. From FY 2017 to FY 2021, Amtrak Annual Grant appropriations averaged approximately $1.88 billion per year. BIL reauthorized the program and significantly increased funding: from FY 2022 to FY 2026, $19.22 billion was authorized for the program, or approximately $3.84 billion per year.

Railroad Rehabilitation and Improvement Financing (RRIF). The RRIF program finances the development of railroad infrastructure by providing direct loans and loan guarantees of up to $35 billion. RRIF funding can be used to acquire and improve tracks and related facilities, develop new intermodal facilities, reimburse planning and design expenses, and finance transit-oriented development. Railroads, state and local governments, government-sponsored authorities and corporations, freight shippers, and joint ventures that include one of the previous entities are eligible for RRIF funding.

Rulemaking on high-speed passenger rail. To encourage the development of high-speed rail, FRA updated their regulations in 2019 to include standards for high-speed rail services, establishing standards for trains that can travel up to 220 miles per hour. The new category of high-speed rail operations makes it possible for high-speed trains to use existing infrastructure. The rulemaking also established safety standards for high-speed trains.

State Rail Plans. States are encouraged (but not required) to prepare a State Rail Plan for submission and acceptance by FRA. State Rail Plans can help to set forth policy about freight and passenger rail, present priorities for enhancing rail service, and serve as a basis for federal and state investments in the state. FRA issued State Rail Plan Guidance in 2013 outlining minimum content requirements, a standardized format, and the review and acceptance process to help states prepare their Rail Plans.

Interstate Rail Compacts Grant Program. This program, created by BIL, provides funding for entities to implement interstate rail compacts. The program's purpose is to improve, promote, and develop intercity passenger rail service. Eligible costs include planning, administration, promotion of passenger rail, and preparation of applications for federal grant programs.

Rail trips for official travel. A December 2023 **General Services Administration directive** encourages federal agencies to reduce GHG emissions from official travel, including choosing rail for trips shorter than 250 miles where feasible and using public transportation while in the destination city.

Amtrak fare discount programs. Amtrak provides discounted fares on many of its services to seniors, children, active-duty military, and veterans. It also provides special deals, group rates, and a frequent traveler program. Making rail more cost-competitive with flying or driving can encourage mode shift.

OPPORTUNITIES

Maintain or increase funding for intercity rail. As noted above, BIL significantly increased federal funding available for passenger rail. To maintain and expand the progress made with BIL funds, passenger rail will need continued investment.

Develop high-speed passenger rail. States, MPOs, and private companies can advance high-speed (and conventional) passenger rail by taking advantage of FRA's Corridor ID funding for planning projects, Federal-State Partnership for Intercity Passenger Rail and Consolidated Rail Infrastructure and Safety Improvements (CRISI) funding for infrastructure development, and public-private partnerships to combine the expertise and resources of the public and private sectors.

Support programs that reduce freight and

passenger rail conflicts. Most Amtrak routes operate on tracks owned by freight railroads, and conflicts with freight trains are the largest source of delay to Amtrak passengers. In 2022, all fifteen of Amtrak's long-distance routes failed to meet FRA's on-time performance standard of 80 percent of customers arriving on time. Their performance ranged from 70 percent on time to just 19 percent on time. Among the shorter state-supported routes, more than half failed to meet the on-time standard.[81] Reducing conflicts between passenger and freight rail would significantly improve the speed and reliability of passenger rail service. A potential focus of this effort could be on coordination of passenger rail and freight schedules, preparing system and process engineering studies into reducing conflicts, and funding direct infrastructure improvements that help prevent conflicts.

Research on mode shift to passenger rail. With an unprecedented level of funding directed toward passenger rail improvements, research is needed on the impacts of different types of infrastructure and operational improvements on ridership and GHG emissions. DOE and other agencies should develop and use new models to estimate the national potential from largescale shifting of intercity passenger travel from personal vehicles and air to rail, including high-speed passenger rail. FTA and FRA could collaborate on rail mode choice research, as lessons learned from research on commuter rail may be relevant to non-commuter rail travel.

STATE, LOCAL, AND INDUSTRY EXAMPLES

Virginia: Right-of-Way Acquisition. In Virginia, the acquisition of right-of-way from track owner CSX Transportation has been a priority strategy to expand rail service options. In addition, capital improvements such as a new passenger-dedicated bridge crossing the Potomac River and an increase in Amtrak service will reduce bottlenecks. Virginia Railway Express, the region's commuter rail service, expects a 60 percent increase in service from these changes, which are one-third the cost of expanding I-95 in Virginia.

Florida: Brightline High Speed Rail. Brightline is the 235-mile-long high-speed railway connecting Miami, West Palm Beach, Fort Lauderdale, Aventura, Boca Raton, and Orlando, with plans of expanding to Tampa. Trains travel up to 125 mph, so passengers can travel between downtown Miami and downtown Fort Lauderdale in 30 minutes and between Miami and Orlando in 3 hours. A December 2023 report shows that ridership increased 29 percent from the prior year. The expansion to Orlando during this period led to an increase of long-distance ridership, which accounted for 49 percent of riders.

ACTION AGENDA

The following represent a selection of promising opportunities for reducing emissions through investments in intercity passenger rail. The table below summarizes these actions and associated lead sectors.

Private Sector	• Invest in high-speed passenger rail. • Produce highly efficient locomotives.
Tribal, State, and Local Governments	• Expand and improve intercity passenger rail, including high-speed rail. This includes increasing availability, frequency, speed, reliability, efficiency, affordability, comfort, and effective connections to transit services.
Federal Government	• Implement Federal Railroad Administration grant programs and Railroad Rehabilitation and Improvement Financing (RRIF).
Research	• Research mode shift effects of strategies to improve and expand intercity passenger rail service.

3.3 Investments in Efficient Freight Transportation Modes

For transporting similar goods over similar distances, rail and maritime shipping are generally more energy efficient and less carbon-intensive than truck shipping, which currently accounts for most of the freight transported in the United States, and air freight, which generally carries high-value or time-sensitive goods. Inland marine shipping can move one ton of freight 675 miles on a gallon of diesel fuel, and rail can move it 472 miles using the same amount of fuel. In contrast, trucks can move one ton of freight 151 miles with a gallon of diesel fuel.[82]

Freight modes are not interchangeable for every single trip; for example, rail could not serve the purpose that trucks do in last-mile deliveries, nor could it replace maritime for overseas trade. Freight logistics managers currently choose the optimal combination of modes to move products based on commodity type and value, distance, timing, reliability, access to markets, and cost. However, investing in freight rail and maritime infrastructure can increase the options available to shippers for lower-carbon, more efficient transport of freight. While the federal government is increasingly investing in rail and port infrastructure through multimodal grant programs, continuing investment in multimodal infrastructure has the potential to unlock better service options for shippers.

Scholarship in recent decades has demonstrated the benefits of transporting more goods by freight rail. A 2017 DOE study found that shifting an estimated 4.1 percent of truck freight activity to rail would reduce total freight energy use and CO_2 emissions by 4.4 percent by 2040.[83] A 2008 study suggested that 25 percent of freight could be shifted from trucks to rail at a lower cost if more rail infrastructure existed, leading to an 80 percent reduction in social costs related to emissions, congestion, and safety.[84] A 2019 International Energy Agency (IEA) study found that up to 100 percent of bulk mineral shipments and up to 60 percent of consumer goods shipments between distribution centers could be shifted from trucking

Maritime shipping offers an alternative to land-based freight modes.

to rail. IEA also found a new freight rail line can offset between 210,000 metric tons and 1.2 million metric tons of CO_2 equivalent per year.[85, d]

Rail's share of freight in the United States declined since 1997, largely due to a decrease in coal shipments.[86] Shippers report that disadvantages in speed, reliability, flexibility, and customer experience are barriers to using freight rail over trucking in some instances. Addressing these areas in freight railroads could help rail maintain or grow its current share of freight travel.[87] The freight rail sector is showing interest in increasing their mode share of freight tonnage. CN recently started a new intermodal service to encourage the shift from truck to rail.[88] The United States is also funding feasibility studies for new US-Mexico intermodal routes, with the hope of shifting additional tonnage from trucks to rail. [89]

Inland waterways have many of the same real and perceived disadvantages as rail when compared to trucks.[90] Inland ports have traditionally been limited by a lack of investment, and many are not prepared to handle large shipments.[91] Investments in inland ports could boost shipments on inland waterways both as a substitute to some truck and rail routes and as a component of multimodal shipments. Finally, the cost and logistical requirements of changing modes can present a barrier to multimodal shipments. Facilitating multimodal transfers through facility upgrades and innovative technology can also promote lower-emission shipments.

Investments in intermodal freight facilities are critical to enabling shippers to combine modes in the same shipment, such as using rail or maritime for the largest distance of a freight shipment and transferring to trucks to reach the final destination. Supporting lower-emission freight modes and intermodal facilities will give shippers more modal choices to optimize the energy efficiency of their shipments. It will also make the freight system more resilient and cost-effective.

[d] The emissions benefits depend on the topology of the area, infrastructure decisions, the operational efficiency of the trains, load factors and electricity mixes, and the volume of freight shifted to rail. The study found that the break-even point—the point at which the higher upfront emissions of constructing a new rail line were offset by the operational emissions savings of displacing truck trips—ranges between 2 and 24 years, depending on the number of road trips avoided.

Freight train double stacked for efficiency.

Emerging modes such as electric cargo bikes and electrified drones may also play an important role in decarbonizing last-mile deliveries. These technologies are covered in more detail in the Convenience Action Plan.

FEDERAL ACTIONS AND INITIATIVES

USDOT Office of Multimodal Freight Infrastructure and Policy. Established by Congress in 2021 and formally launched at a White House event in November 2023, the Multimodal Freight Office is tasked with carrying out the National Multimodal Freight Policy, including facilitating information sharing between the private and public sectors, conducting research on improving multimodal freight mobility, and assisting and liaising with cities, states, and federal departments on multimodal freight and supply chain expertise. Its mission of enhancing multimodal freight mobility will help to identify and enhance efficiencies within the freight sector through multimodal connectivity. USDOT plans to designate a National Multimodal Freight Network in 2024 that supports the use of and shift to lower carbon modes.

State Freight Plans. States are required to complete State Freight Plans consistent with federal requirements in order to expend allocated funding under the National Highway Freight Program. Completing a State Freight Plan offers states the opportunity to evaluate freight movement trends across all modes and identify priority policies and investments to meet their goals and the goals of the National Multimodal Freight Policy.

Consolidated Rail Infrastructure and Safety Improvements Program. FRA's CRISI program funds projects that improve the safety, efficiency, and reliability of freight and intercity passenger rail. Under BIL, annual CRISI funding increased substantially to $1.4 billion in 2022. CRISI funds can be used for a wide variety of projects supporting the development of rail, ranging from capital investments to workforce development and training, to research and development, and more.

ARPA-E Intermodal Freight Transportation System. The DOE's Advanced Research Project Agency-Energy (ARPA-E) announced funding under the exploratory topic Increasing Transportation Efficiency and Resiliency through MODeling Assets and Logistics (INTERMODAL) to fund projects that develop technology to model the low-carbon intermodal freight transportation system of the future.[92] The projects are expected to reduce emissions by enabling prioritization of low-carbon energy infrastructure deployment, along with data required for the effective deployment of this optimized distribution system.

Freight Logistics Optimization Works (FLOW). This tool, developed by USDOT in partnership with supply chain industry partners, provides an industry forum combined with an information exchange platform to help address supply chain challenges and enable a resilient and globally competitive twenty-first century freight network. The collaborative forum will help the private and public sectors identify opportunities for operational efficiencies and mode shift in the nation's freight network.

Port Infrastructure Development Program (PIDP). This discretionary grant program overseen by the USDOT Maritime Administration (MARAD) aims to improve port and related freight infrastructure. The PIDP funds port improvements, including those with decarbonization and resilience co-benefits, in rural and urban areas nationwide. It also includes a set-aside to improve capacity at smaller ports. By improving maritime freight infrastructure, the PIDP improves the availability of maritime shipping and makes it a more viable option compared to higher-carbon modes of freight transport.

United States Marine Highway Program. MARAD's United States Marine Highway Program is a transportation grant program to support projects that provide a coordinated and capable alternative to landside transportation by promoting marine highway transportation through the nation's navigable waterways. The Marine Highway system currently consists of 31 Marine Highway Routes. By developing and broadening crucial shipping corridors, the program offers an alternative to landside transportation corridors and higher-emission modes of freight transportation.

Other USDOT funding streams that could support more efficient freight movement. Other climate- and efficiency-related funding opportunities for freight include USDOT's Rebuilding American Infrastructure with Sustainability and Equity (RAISE), INFRA, Mega, and Transportation Infrastructure Finance and Innovation Act (TIFIA) programs. The Federal Highway Administration's (FHWA) CMAQ Program may also be used to improve intermodal freight facilities when an air quality benefit can be shown.[93] FRA maintains a more complete list of rail industry climate-related funding opportunities.

OPPORTUNITIES

Promote efforts to reduce freight-related emissions through multi-modal freight planning. States are required to develop State Freight Plans to obligate National Highway Freight Program formula funding. As part of these plans, States are required to develop goals and strategies to reduce the impacts of freight movement on local air pollution and emissions. Identifying areas of consistency and shared goals between Carbon Reduction Strategies prepared pursuant to the Carbon Reduction Program and State Freight Plans would ensure both plans are aligned toward reducing emissions of GHGs and other pollutants.

Research the potential emissions savings of freight modal shift. DOE and other agencies should use new models that are being developed under the INTERMODAL program to estimate the national potential emissions savings from shifting freight movements from trucks and air to rail and maritime, considering the criteria that suppliers and receivers use to decide how to ship specific commodities. In addition, DOE and other agencies should use their existing modeling capabilities to determine the potential for reducing energy use from last-mile delivery of urban goods and packages in regions, using electric delivery vans, delivery lockers, micromobility, air- or ground-based drones, etc. Last-mile deliveries are covered in more detail in the Convenience Action Plan.

Develop research and tools for multimodal hubs. Multimodal hubs play a crucial role in facilitating efficient transportation networks. Ongoing research focuses on identifying tools and strategies that can optimize these hubs to promote mode shift, encouraging the seamless transition between different modes of transportation and improving the overall efficiency of freight transportation. By combining multiple modes rather than solely relying on a single mode like trucking, multimodal hubs can maximize the efficiency of freight movement. This approach enables the utilization of each mode's strengths and mitigates their limitations.

The development and implementation of tools that streamline and synchronize multimodal operations are crucial in achieving this goal, allowing for smoother transfers and reducing bottlenecks at these hubs. Such tools could include planning tools, data and communication tools, and common standards and specifications across different modes to facilitate sharing between different modes, improve the efficiency of modal transfers, and harness automation for increased efficiencies. Recognizing that airports serve as important multimodal hubs for both passengers and freight, the federal government could also expand support of research and provide investments to improve the efficiency of multimodal transfers at airports. Multimodal hubs can also play a role in the transition to clean fuels by providing multimodal charging and fueling stations for electricity, hydrogen, and other alternative fuels.

Support freight railroad operations and infrastructure. The following freight rail investments can support more informed mode selection, improve access, and lead to long-term efficiency gains and emissions reductions:

1. Increase industrial access to rail by adding (or reviving existing) spur lines.
2. Coordinate scheduling between short-lines and Class I Railroads to increase origin-to-destination reliability across the entire system to compete with long-haul trucking.
3. Build out a carload-centric rail system in which import and export docks have direct rail access.
4. Use inter-line partnerships to address unserved or underserved lanes that require interchange.
5. Invest in transload and industrial parks with rail centric offerings (bring the freight to the railroad).
6. Penetrate shorter haul intermodal lanes where market share is low for rail.

Invest in inland ports and short sea shipping. While the maritime industry carries the majority of international trade, there remains a significant opportunity to promote domestic shipping along the coasts and within the inland waterways. Additionally, increasing available liner services for short sea shipping would offer an alternative to portions of the logistics chain that are only served by rail and trucks.

Implement partnerships with the rail industry. FRA can partner with the rail industry to research and implement new technologies to improve intermodal operations and compete with short-haul trucking.

STATE, LOCAL, AND INDUSTRY EXAMPLES

Heartland Rail Corridor Project. The Heartland Corridor is a 529-mile rail corridor connecting the Port of Virginia in Newport News, VA, to Chicago, IL, that opened for travel in 2010. The corridor was constructed through five separate projects in Virginia, West Virginia, Kentucky, and Ohio to accommodate intermodal containerized freight along the rail line.[94] Upgrades included increasing the clearances in 28 tunnels and 24 overhead obstructions, constructing three new intermodal facilities, relocating existing tracks, and constructing new tracks. The projects were funded and constructed through a public-private partnership between Norfolk Southern Railroad, USDOT, and various state agencies. For double-stacked container trains, the project reduced the travel distance between Newport News and Chicago by nearly 200 miles, and it cut the travel time from three days to two.[95] In doing so, the project made rail travel between the two cities more efficient and made rail more competitive with trucking. Rail intermodal corridors like the Heartland Corridor provide the means of shifting freight to nonhighway modes to alleviate congestion, reduce GHG emissions, and enhance reliability.

New York, NY: Blue Highways Program. New York City's Economic Development Corporation (EDC) and Department of Transportation are seeking to move more freight from the city's roadways to its waterways. Through the Blue Highways Program, the City seeks to modernize its marine infrastructure, expand access to its waterfront, and develop a model for clean and efficient last-mile deliveries.[96] EDC will invest in freight hubs in six locations throughout the city. Barges at each hub would allow vessels to offload shipment inventory closer to its final destination for last-mile delivery on low- and zero-emission vehicles like cargo bikes and electric vans.[97] The upgrades could reduce up to an estimated 40 million truck miles per year, 65,000 metric tons of GHG emissions, and 24,000 pounds of particulate matter per year.[98]

Maine's Industrial Rail Access Program. Maine is one of several states that have an Industrial Rail Access Program (IRAP) to generate new or expanded rail service to businesses in the state, stimulate economic and employment growth, and improve the efficiency of the freight system through promoting the use of freight rail and intermodal transportation. IRAP provides funding to businesses and shippers to invest in freight rail infrastructure. In 2024, the program will distribute $2 million.[99]

Short haul rail for freight movement. In conjunction with Georgia Central Railway and Heart of Georgia Railroad, Parallel Systems is developing a unique zero-emission modular rail car that is designed to use existing rail infrastructure for short haul movement of single freight containers. The G&W companies are supporting the development of this freight solution to compete with the short haul road freight trucking market (less than 400 miles). The technology has the potential to reduce diesel fuel used in the freight sector by 33 billion gallons annually and offset up to 4.5 percent of all U.S. carbon emissions. ARPA-E has provided grant funding and FRA's Office of Railroad Safety (RRS) has provided technical support to the G&W companies and Parallel Systems as they developed the freight vehicle concept and testing approach.[100]

ACTION AGENDA

The following represent a selection of promising opportunities for reducing emissions through investments in efficient freight transportation. The table below summarizes these actions and associated lead sectors.

Private Sector	• Consider emissions impacts of shipping options. • Invest in freight railroad infrastructure and operations. • Invest in inland ports and short sea shipping. • Reduce freight and passenger rail conflicts to improve speed and reliability.
Tribal, State, and Local Governments	• Develop intermodal freight hubs. • Support freight railroad operations and infrastructure. • Invest in inland ports and short sea shipping.
Federal Government	• Implement Federal Railroad Administration, Maritime Administration, and multi-modal grant programs. Implement Railroad Rehabilitation and Improvement Financing (RRIF). • Designate a National Multimodal Freight Network in 2024 that supports the use of and shift to lower carbon modes.
Research	• Research mode shift effects of strategies to improve and expand rail and maritime capacity. Model low-carbon intermodal freight transportation options.

3.4 Improvements in the Operation of Transportation Systems

Transportation systems operations, meaning the operation of the infrastructure and vehicles that move goods and people, can be improved and optimized to reduce energy use and emissions. Innovative technologies, such as eco-routing algorithms, eco-approach and departure at intersections, eco-traffic signal timing, or platooning technology, can improve the efficiency of transportation assets and services.[101] Just-in-time queuing or optimizing freight capacity for each trip can improve freight operations and logistics, reducing fuel consumption and emissions. Real-time data can allow transportation systems to operate more efficiently and respond to changes and unexpected delays, due to congestion or other traffic incidents, more effectively. For example, more efficiently managing truck deliveries to ports through improved scheduling, automated gate systems, and other strategies can reduce emissions from trucks idling waiting to unload their cargo. Additionally, regulations and rulemaking can be leveraged to reduce emissions and improve the operational safety of transportation systems. For example, at the federal level the USDOT Pipeline and Hazardous Materials Safety Administration (PHMSA) recently proposed a rule that strengthens leakage survey and repair requirements on gas pipelines, reducing GHG emissions from pipeline leaks. States and local authorities, such as the California Air Resources Board, have implemented a variety of anti-idling regulations meant to curb the emission of pollutants from idling vehicles.[102]

While these efficiency improvements can alleviate traffic congestion and significantly reduce emissions, they could also result in additional travel demand. Research has demonstrated that cheaper and faster travel encourages more trips and trips of longer distances.[103, 104] This induced demand, or rebound effect, would offset some of the benefits from transportation system level efficiency improvements or, depending on the magnitude, could even lead to higher overall emissions. Induced demand can be addressed through a variety of Transportation Demand Management (TDM) strategies, including congestion pricing programs, parking pricing adjustments, or financial incentives such as "cash out" programs for employee parking. The Convenience Action Plan includes a more detailed discussion of induced demand and TDM strategies.

FEDERAL ACTIONS AND INITIATIVES

EPA Ports Initiative. Through this partnership initiative, EPA supports efforts to improve efficiency, enhance energy security, save costs, and reduce harmful health impacts by advancing next-generation clean technologies and practices at ports. The Ports Initiative provides funding, technical resources, collaboration, and coordination to port stakeholders, and is the foundation for EPA's $3 billion Clean Ports Program, which will fund grants to implement zero emission technologies as well as climate and air quality planning at ports across the United States The Ports Initiative also curates best practices and case studies of steps that can reduce air pollutant and GHG emissions from ports through efficiency gains. For example, the Ports Initiative includes a suite of operational strategies port operators can employ to accomplish substantive emissions reductions as well as time and cost savings.

Reduction of Truck Emissions at Port Facilities. This FHWA grant program provides funding to reduce truck idling and emissions at ports through the advancement of operational efficiency improvements and infrastructure to support electrification.

Saving Lives with Connectivity: Accelerating Vehicle-to-Everything (V2X) Deployment. This FHWA grant program funds projects that advance connected and interoperable vehicle technologies. The initiative is focused on road safety, mobility, and efficiency through technology that enables vehicles and wireless devices to communicate with each other and with roadside infrastructure to provide warnings.[105]

Saving Energy with Connectivity. In collaboration with USDOT, DOE announced a funding opportunity for FY 2024 called Saving Energy with Connectivity. Projects will develop and deploy approaches using V2X high-speed, low latency communication to improve the efficiency and convenience of the mobility-system. Projects could include but are not limited to eco-driving along connected corridors, transit priority, intermodal optimization, or freight priority. Projects under this program will culminate in the deployment of hardware in real-world settings, serving as a model for future deployment.

Advanced Transportation and Innovative Mobility Development (ATTIMD)/Advanced Transportation Technology and Innovation (ATTAIN). This FHWA grant program supports the deployment, installation, and operation of advanced transportation technologies. Eligible activities that advance transportation system efficiency include implementing technology to enhance high occupancy vehicle toll lanes, integration of transportation service payment systems, and deploying advanced mobility access and on-demand transportation service technologies such as dynamic ridesharing and other shared-use mobility applications, which utilize smaller vehicles on dynamic routes rather than large vehicles on fixed routes in conventional transit service.

21st Century Truck Partnership Freight Operational Efficiency (21CTP). The 21CTP is a pre-competitive research collaboration among the major manufacturers of trucks and the federal government (DOE, USDOT, DOD, and EPA). Within 21CTP, the Freight Operational Efficiency technical sector team has developed a technical roadmap to highlight the major research and deployment gaps and opportunities associated with improving transportation system operation. This roadmap explores opportunities in technologies, data analysis, and operational practices to inform the research community on future research and deployment efforts. To provide additional information on truck operations, the Bureau of Transportation Statistics (BTS) provides data on physical and operational characteristics of U.S. trucks through the Vehicle Inventory and Use Survey (VIUS). Similarly, DOE National Renewable Energy Laboratory (NREL) provides information on medium- and heavy-duty vehicle technologies through the Fleet Research, Energy Data, and Insights portal.

Strengthening Mobility and Revolutionizing Transportation (SMART). This USDOT grant program funds demonstration projects focused on advanced smart community technologies and systems that improve transportation efficiency and safety. Eligible projects include connected vehicles, delivery/logistics, sensors, system integration, coordinated automation, aviation innovation, smart grid, and traffic signal innovation.

Exploratory Advanced Research (EAR) Program. This FHWA program is exploring the development of artificial intelligence (AI) and machine learning technology within the surface transportation sector. The EAR program has also funded several computer vision research projects to enhance the safety and efficiency of surface transportation.

Enhance intermodal efficiency. USDOT offers grant funding to enhance intermodal efficiency through several programs, including the Reduction of Truck Emissions at Port Facilities Grant Program, the National Highway Freight Program, and the Accelerated Innovation Deployment Demonstration Program.

Technology Commercialization Fund (TCF). Through the TCF, DOE provides funding to support the commercialization of technologies developed by DOE National Labs. For example, through the TCF program DOE is co-leading a project with Argonne National Laboratory to enhance the usability of the Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (R&D GREET) tool for industries. A more accessible and comprehensive interface for R&D GREET will aid the commercialization of new technologies by making it easier to analyze potential emissions mitigation opportunities and the potential impacts of new technologies.[106]

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR). A number of federal agencies including USDOT, EPA, and DOE provide funding under the SBIR program, and DOE and others under the STTR program. DOE announced a funding opportunity under SBIR and STTR for research to improve energy efficiency and material productivity, and to drive economy-wide decarbonization.[107] USDOT's annual Phase I SBIR solicitation includes a wide range of topics focused on developing solutions that address operating administration needs, including sustainability and energy-related objectives.

SAFESPECT Screening Platform. In September 2022, the USDOT Federal Motor Carrier Safety Administration (FMCSA) announced the next general digital inspection platform for commercial vehicle roadside safety inspections. SAFESPECT will improve the efficiency of inspections and decrease wait and vehicle idling time at inspection stations.

EPA SmartWay. This EPA program is an industry partnership program that provides carriers, shippers, and logistics partners with a standard approach to measure emissions generated by their freight and shipping operations. SmartWay emissions inventories help partners assess the efficiency gains (environmental benefits) of freight network investments (technology and digital intelligence) in conjunction with projected financial returns. Partners use SmartWay emissions inventories for benchmarking, monitoring, and publicly reporting progress toward achieving their emission reduction goals.

BEYOND Program. The USDOT Federal Aviation Administration (FAA) is working with state, local, and Tribal governments to pilot complex unmanned aircraft system, or drone, operations. The governments and their industry partners explore new ways to provide existing services using drones to perform inspections, dispense agricultural products, and deliver packages, in place of less efficient vehicles such as helicopters, agricultural aircraft, and LDVs. In addition to being pathfinders for safe operations in the National Airspace System, these emerging entrants demonstrate ways to reduce fuel emissions, "non-exhaust" pollution, and traffic congestion, while improving worker safety and services to disadvantaged communities.

Cooperative Driving Automation. FHWA's CARMA Program is leading research on cooperative driving automation (CDA), which would enable communication and cooperation between properly equipped vehicles and infrastructure. DOE also supports CDA research through the ARPA-E NEXTCAR Program and research funding for New Mobility Systems. DOE's portfolio of work includes defining and developing communication requirements to implement energy centric CDA applications, including information messages exchanged, required communication latency, frequency, bandwidth, and other state-of-the-art requirements as well as evaluate their impacts on energy efficiency over a range of scenarios. DOE's CDA research includes optimizing the signal phase and timing of traffic signals and connected vehicle/connected and automated vehicle trajectory planning along multi-intersection arterials and highways. CDA technologies have the potential to reduce congestion, increase the capacity of the road network by shortening headways between vehicles, and increase the safety and efficiency of travel on roadways.[108]

Metrics and modeling. DOE, in collaboration with NREL, developed the Mobility Energy Productivity (MEP) metric to quantify the ability of an area's transportation system to connect individuals to goods, services, employment opportunities, and other activities, by travel mode, while accounting for time, cost, and energy.[109] DOE's Lawrence Berkeley National Laboratory (LBNL) developed the Individual Experienced Utility-Based Synthesis (INEXUS). INEXUS is a suite of accessibility metrics that measure agent-trip level accessibility. These metrics can be used to identify and measure individual travelers who benefit from improved mobility under different simulation scenarios. Tools such as these can be used to design for improved operational efficiency in existing and future transportation systems.[110]

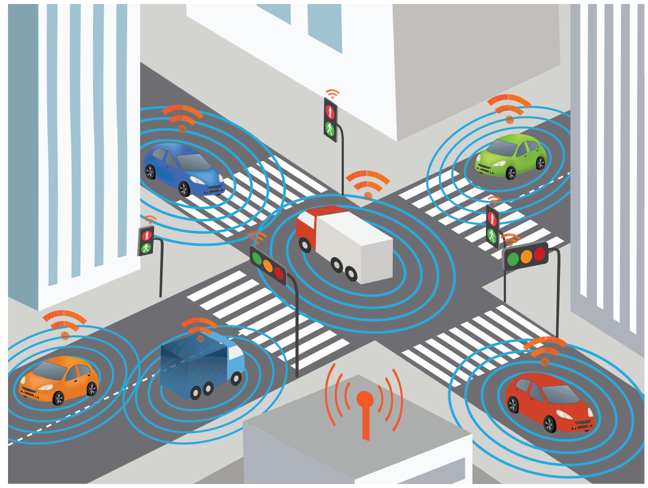
Pipeline operational safety. PHMSA has developed new and proposed rules to reduce emissions by improving the operational safety of pipelines. Fixing pipeline leaks is a core part of the U.S. Methane Emissions Reduction Action Plan, which aims to enhance safety, reduce pollution, and cut energy waste. PHMSA has developed new and proposed rules to reduce emissions by improving the operational safety of pipelines. These new rules include the Gas Pipeline Leak Detection and Repair proposed rule, the Safety of Gas Distribution Pipelines proposed rule, and the Amendment to Liquefied Natural Gas Facilities rule under development. Additionally, PHMSA offers grant funding through the Natural Gas Distribution Infrastructure Safety and Modernization Grant Program to repair, rehabilitate, or replace natural gas distribution pipeline systems prone to leakage.

Optimize flight trajectories. At the USDOT, the FAA, in partnership with the National Aeronautics and Space Administration (NASA), is developing tools to automatically optimize aircraft trajectories to reduce fuel use.

Additive manufacturing. FAA is exploring the use of additive manufacturing for aircraft parts. Additive manufacturing, or 3D printing, allows manufacturers to create specific parts onsite to shorten their supply chains.[111]

OPPORTUNITIES

Continue to invest in research and development for intelligent transportation systems (ITS). As innovative transportation technologies emerge, there could be more opportunities for federal agencies to invest in research and development efforts geared towards technologies focused on decarbonization. For example, the USDOT ITS Joint Program Office (ITS JPO) conducts research and supports the deployment of various ITS technologies that can support a more efficient transportation system, such as Vehicle-to-Everything (V2X) and other emerging and enabling technologies. Additionally, DOE's EEMS Program conducts research, develops tools, and runs demonstration projects to simulate the effect of technologies and policies in reducing energy use and emissions in regional transportation systems. The EEMS program has funded development of two agent-based models, POLARIS at Argonne National Laboratory (ANL) and BEAM CORE at LBNL and NREL, that simulate the multimodal travel of individual travelers and vehicles throughout a region under different technology and policy scenarios. The federal government can make use of tools such as these to strategize on the effective deployment of these technologies for practitioners at all levels of government and within the private sector.



Intelligent transportation systems can support efficiency improvements in our transportation systems.

Support ITS tool deployment for truck parking scheduling and route planning projects. The federal government can provide technical assistance and highlight successful deployment of ITS tools for specific applications such as truck parking and route planning. ITS tools for these applications could reduce GHG emissions by reducing deadheading and extra mileage.

Advance high performance computing applications. Advancements in computing power such as quantum computing, edge computing, or cloud computing are enabling computers to solve massively complex problems. Improvements in data storage and processing have the potential to transform transportation research and technology. High performance computing could drastically improve the efficiency and safety of transportation systems by enabling high-speed connectivity and enhancing real-time decision-making and analytics. The federal government could support research into high performance computing applications for transportation.

Research and provide guidance on eco-routing. The federal government can support research and develop guidance for implementing eco-routing technologies. Eco-routing technologies plot the most energy or fuel-efficient route for vehicle travel, potentially improving the energy or fuel efficiency across the transportation network.[112, 113] Modeling by DOE demonstrates that universal use of a Vehicle to Infrastructure (V2I) and eco-driving application could reduce energy use 24 percent across the transportation system. DOE also finds that deployment of an eco-automated traffic control system—which minimizes stops and prioritizes transit vehicles and vulnerable road users—could reduce fuel use from vehicle stops and delays by 25 percent. Finally, an on-road demonstration showed that eco-driving EVs could reduce energy use between three and 57 percent under various demonstration scenarios.[114]

Data sharing. Federal, state, and local officials could work with private transportation providers to increase data sharing between modes to better understand and identify potential efficiency improvements for freight and passenger transportation. For example, increased data sharing could complement the usability of existing tools, such as the BTS Freight Analysis Framework (FAF) database, for implementing freight efficiency improvements. The FAF contains freight flow data sourced from a variety of sectors, providing a national and regional context for local data collection efforts to understand local details to support freight analysis and inform decision-making. The database provides a comprehensive summary of current freight trends and can be used to predict future trends. Additionally, data collection and sharing between ports could support ongoing efforts and future opportunities to improve the efficiency of drayage trucks. Data sharing could help in identifying and deploying strategies such as automated gate systems and truck appointment systems to reduce emissions from idling and congestion.

Development of real-time traveler information systems for freight operations. Development and research of tools and applications to support real-time traveler information could reduce emissions from freight operations. For example, ITS JPO developed and tested an ITS-driven bundle of applications called the Freight Advanced Traveler Information System (FRATIS), designed to improve freight operations.[115] Although the FRATIS pilot concluded in 2013, FRATIS could be expanded and refined to include more dynamic information-based systems. BTS's FLOW tool, described previously, can also facilitate the development of collaborative real-time information systems.

Advance the implementation of new rail technologies. The rail industry is developing and implementing new technologies, refining operating practices, and working with their suppliers to reduce GHG emissions. These investments include expanding the use of automated gate systems, exploring the use of alternative fuels, and developing fuel management and network optimization systems. According to the American Railroad Association, every Class I railroad has approved GHG reduction targets through the Science-Based Targets initiative, a non-profit partnership that reviews and tracks private sector climate actions.[116] Continuing to implement these and other new technologies will help railroads meet these GHG reduction targets.

Example of a Truck Stop Electrification installation (an auxiliary HVAC unit) to reduce truck idling for cooling/heating.

STATE, LOCAL, AND INDUSTRY EXAMPLES

Truck Parking Information Management System. Eight member states of the Mid America Association of State Transportation Officials, with FHWA grant funding, developed the Truck Parking Information Management System to provide real time parking availability to drivers along major freight corridors. Truck parking information systems collect and broadcast real-time parking availability to drivers so that drivers may proactively plan their routes and make safer and smarter parking decisions.

Port of New York and New Jersey: Truck Appointment System. In 2017, the Bayonne terminal of the Port of New York and New Jersey introduced an upgraded truck appointment system to reduce truck idling, congestion, and the terminal's carbon footprint. The new system increased efficiency in terms of shorter and consistent turn times, fuel cost savings, and traffic management, helping to spur economic growth at the port. The system has also reduced emissions and idling time, reduced 21,000 metric tons of carbon dioxide emissions per year (equivalent to removing 4,500 cars off the road), reduced 61 metric tons of air pollutants per year, and saved $5.3 million in fuel costs per year.

Port of Los Angeles: Maritime Shipping Data Portal. In 2017, the Port of Los Angeles and Wabtec launched the Port Optimizer, an information portal designed to digitize maritime shipping data for cargo owners and supply chain stakeholders through secure, channeled access. Port Optimizer enhances supply chain performance through real-time, data-driven insights in a single portal.

New Jersey: Truck Stop Electrification. Some truck stops provide electric power pedestals to allow truck drivers to maintain access to air conditioning, heat, and electricity during mandated rest periods without idling their vehicles. In 2018, a truck stop electrification site at the Flying J Travel Plaza in Carneys Point, New Jersey, saw 19,000 billable hours of service, representing 227 metric tons of mitigated emissions and saving nearly 19,000 gallons of diesel fuel.

Port of Seattle: Shore Power. Shore power infrastructure has the potential to significantly reduce emissions by enabling vessels to turn off their engines and maintain access to auxiliary systems like air conditioning or lighting. In 2019, 85 of 95 vessels with shore power-equipment at the Port of Seattle Terminal 91 connected to shore power, reducing CO_2 equivalent emissions by an estimated 3,000 metric tons.

New York: Niagara International Transportation Technology Coalition (NITTEC). The NITTEC compiles regional border wait time data and publishes estimated wait times through its website, a mobile application, text messages, and email alerts. Truck drivers and the public can use this information to improve decisions on when to plan border crossings. NITTEC's online travel information clearinghouse has reduced congestion and improved freight efficiency at the border, as travelers make more informed decisions about where and when to cross.

Texas: Carbon Reduction Strategy V2I Technology. The Texas Carbon Reduction Strategy includes the installation of V2I technology on key freight corridors to improve communication and traffic flow along the highway network. The technology upgrade aims to improve the safety and efficiency of current systems and support strategies to reduce transportation emissions.

ACTION AGENDA

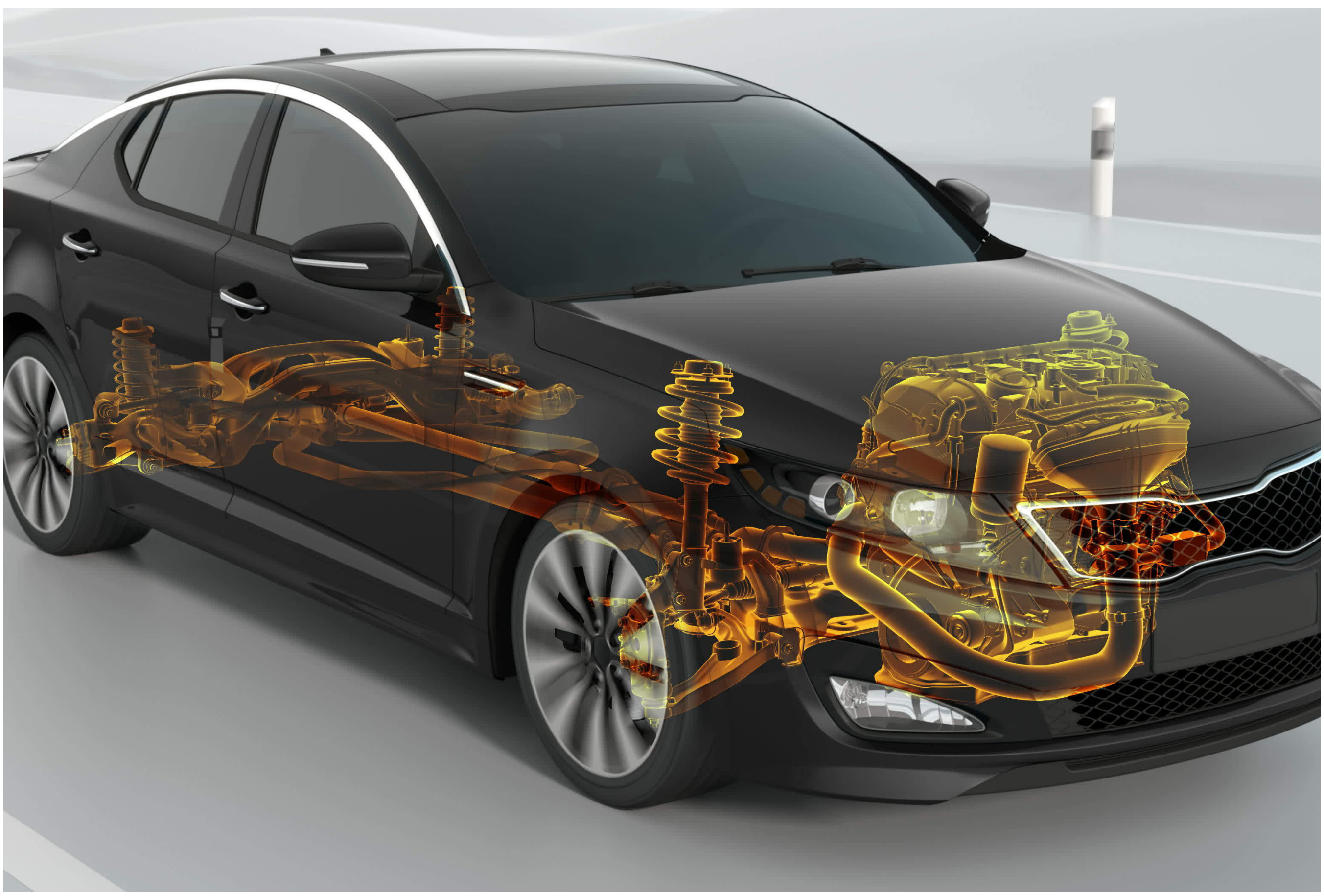
The following represent a selection of promising opportunities for reducing emissions through operational improvements. The table below summarizes these actions and associated lead sectors.

Private Sector	• Optimize flight trajectories. • Design highly efficient aircraft. • Implement data sharing, digital platforms, and real-time freight and traveler information systems.
Tribal, State, and Local Governments	• Optimize traffic signal timing and improve traffic flow.
Federal Government	• Implement EPA Ports Initiative. • Implement FHWA Reduction of Truck Emissions at Port Facilities program. • Implement digital truck inspections to reduce idling at inspection stations. • Implement EPA SmartWay program. • Develop regulations to reduce methane leaks from pipelines. • Develop and implement tools to optimize flight trajectories.
Research	• Research on potential operational efficiencies of emerging technologies.

3.5 Improvements in the Energy Efficiency of Vehicles

While achieving the long-term goal of decarbonizing the transportation sector requires transitioning to cleaner vehicles and fuels, it is also critical to continue improving vehicle efficiency through improved engines, rightsizing, more extensive use of lightweight materials, enhanced aerodynamics, and hybridization or mixed use of fuels.

Conventional vehicles with internal combustion engines, which include vehicles with hybrid electric and plug-in hybrid electric powertrains, will continue to be sold and used over the next decade or more, so improving their efficiency will be an important lever to reduce GHG emissions from the transportation sector. Similarly, efficiency improvements for zero-emission vehicles, such as EVs, will reduce the electricity demand from their use, extend their driving range, and ease the transition to cleaner options. More efficient EVs also enable smaller batteries, which lowers the cost of the vehicle and the amount of critical minerals needed. Efficiency improvements for zero-emission vehicles also have the added benefit of reducing their energy-related cost of operation, which could incentivize their adoption.[117, 118] In the rail sector, addressing air leaks in braking systems could reduce locomotive GHG emissions by an estimated five to 14 percent depending on operational profiles.[119] Companion action plans provide additional information on the Clean strategies, including additional information about federal EV programs; for more information and to download these plans when available, see the Decarbonization Blueprint website.



Improving the energy efficiency of all modern vehicles while maintaining safety and performance is a key strategy.

On average, the fuel economy of new vehicles improved roughly 50 percent over the past 20 years. Sedans and wagons improved from 22.9 miles per gallon (mpg) in 2000 to 32.3 mpg in 2021. The average fuel economy of new SUVs classified as trucks also improved over this time period, from 16 mpg to 24 mpg, but is still significantly lower than that of sedans and wagons.[e, 120] However, over the same time period, the market shifted to more car-based crossover vehicle types, many of which are classified as either "car SUV" or "truck SUV" based on vehicle attributes. In 2011, 41 percent new LDVs were classified as "trucks" under USDOT and EPA regulations. By 2021, that percentage had steadily grown to 63 percent, sparked mostly by increased consumer adoption of crossovers and SUVs.[f, 121] As a result, the emissions benefits of improved fuel economy have been partially offset by the preference towards larger vehicles. This same dynamic applies to EVs. Recent research finds a strong positive relationship between energy consumption and vehicle mass for EVs, meaning that smaller EVs use less electrical energy per mile driven than larger EVs.[122] Efforts to improve the energy efficiency of vehicles should take into account this trend of increasing vehicle mass.

[e] The EPA further separates the car and truck regulatory classes of light-duty vehicles into five vehicle types based on their body style classifications under the CAFE and GHG Regulations. SUVs that are considered trucks under the CAFE and GHG Regulations are classified as Truck SUVs by the EPA.

[f] The majority of this increase in SUVs comes almost entirely from growth in car-based crossover utility vehicles, or CUVs, that use unibody construction, which are lighter and have higher fuel economy than conventional truck-based sport utility vehicles, that use frame-on-rail construction. However, CUVs on average weigh more and have lower fuel economy than conventional sedans and wagons.

Passenger Vehicle Greenhouse Gas Emissions Scenarios

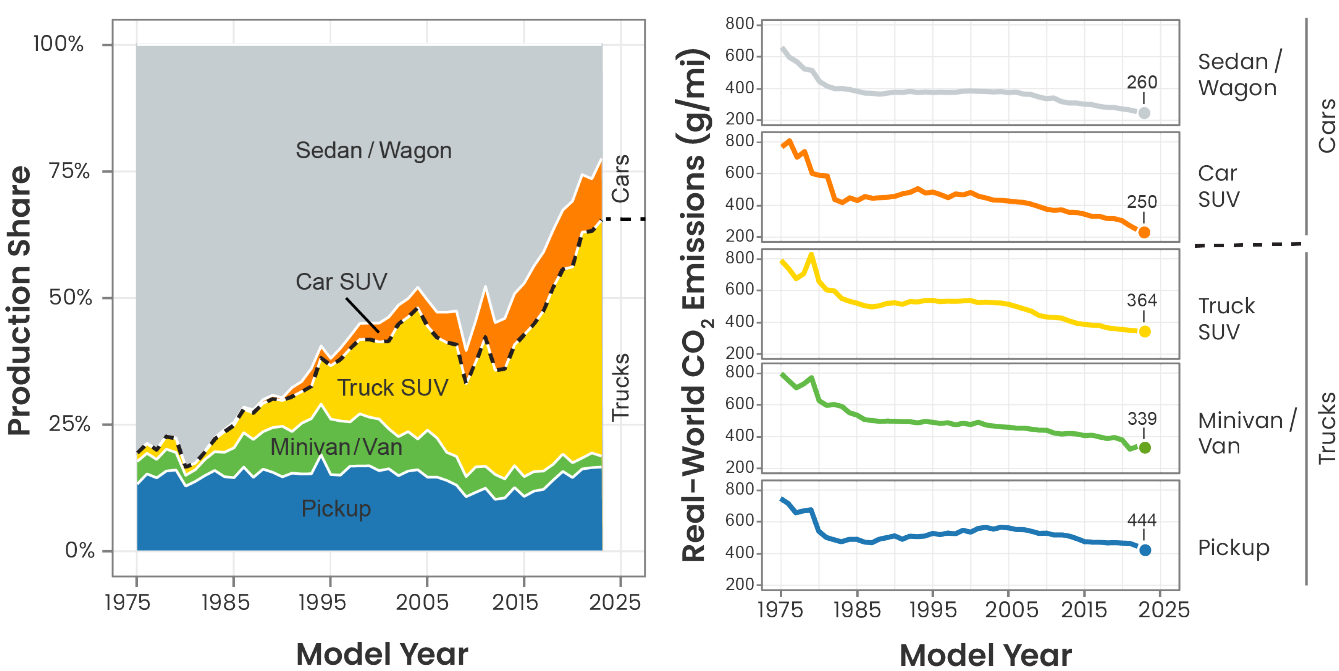


Figure 9: Production Share and CO_2 Emissions by Vehicle Type. Note: EPA further separates the car and truck categories into five vehicle type categories based on body style classification.[123]

As with transportation system efficiency improvements, lowering the cost of travel through vehicle-level energy efficiency improvements can lead to higher transportation demand which could offset some of the environmental benefits.[124] An analysis published by the EPA in 2015 finds that the long-run rebound effect from fuel efficiency standards from 1966 to 2009 was between 28 and 30 percent.[125] A more recent review, incorporating analyses of large databases of odometer readings of individual vehicles, found a central value of 10 percent.[126]

FEDERAL ACTIONS AND INITIATIVES

Corporate Average Fuel Economy (CAFE) Standards. The CAFE standards regulate how far an average vehicle must travel on a gallon of fuel. The USDOT National Highway Traffic Safety Administration (NHTSA) finalized new CAFE standards in June 2024. These standards establish new fuel economy regulations for passenger cars and light trucks through 2031, and heavy-duty pickups and vans through 2035. The standards will avoid the consumption of billions of gallons of gas from vehicles through 2050.[127] Additionally, NHTSA estimates that these standards will save consumers billions of dollars on fuel over the vehicles' lifetimes. While statute does not permit NHTSA to take electric and other alternative fuels into account when setting the CAFE standards, car manufacturers may use these technologies to meet the fuel economy requirements.[128]

Vehicle Emissions Standards. EPA sets emissions standards for criteria pollutants and GHG emissions from vehicles and engines. In March 2024, EPA issued final rules for light-duty and medium-duty vehicles, and separately for heavy-duty vehicles, that will significantly reduce emissions from new vehicles produced in model year 2027 and beyond. EPA's final standards for light-duty and medium-duty vehicles are expected to avoid more than seven billion tons of carbon emissions and provide nearly $100 billion of annual net benefits to society, including $13 billion of annual public health benefits due to improved air quality and $62 billion in reduced annual fuel, maintenance, and repair costs for drivers.[129] Additionally, EPA's final rule for heavy-duty vehicles is expected to avoid one billion tons of GHG emissions and provide $13 billion in annualized net benefits to society from public health and climate improvements and savings for truck owners and operators.[130] EPA also establishes regulations for vehicle testing procedures to show compliance with the emissions standards.[131] Reducing vehicle emissions of harmful air pollutants, which disproportionately impact environmental justice communities,[132] improves air quality and human health. EPA's standards differ from NHTSA's CAFE standards in that they target specific air pollutants, including GHGs such as CO_2 and criteria pollutants such as particulate matter, hydrocarbons, and nitrogen oxides, rather than overall vehicle fuel economy. EPA and NHTSA work closely in establishing their respective emissions standards and fuel economy standards to align the programs to the extent possible given each agency's unique statutory responsibilities.

Maritime Environmental and Technical Assistance (META) Program. This MARAD program supports the research, demonstration, and development of emerging technologies that improve maritime industrial environmental sustainability and efficiency. The META program has supported research and demonstration technologies such as exhaust gas treatment systems, thermal energy harvesting, and general energy efficiency measures for ships.

Diesel Emissions Reduction Act (DERA) Program. This EPA program provides funding assistance to accelerate the upgrade, retrofit, and turnover of the legacy diesel fleet. Eligible diesel emissions reduction solutions include verified retrofit, idle reduction and aerodynamic technologies, and certified engine, vehicle, or equipment replacement. The Diesel Emissions Quantifier (DEQ) tool is used to estimate reductions in CO_2 and other air pollutants from DERA projects.

Airplane fuel efficiency. The FAA released a final rule in February 2024 to reduce carbon pollution emitted by most large airplanes flying in U.S. airspace by requiring incorporation of improved fuel-efficient technologies for airplanes manufactured after January 1, 2028, and for subsonic jet airplanes and large turboprop and propeller airplanes that are not yet certified. The FAA rule provides the enforcement mechanism for an airplane GHG standard the EPA set in 2020. The EPA and FAA are currently working at the International Civil Aviation Organization (ICAO) to develop a new tier of GHG standards for future years.

Aviation efficiency research. FAA provide grants through the Fueling Aviation's Sustainable Transition (FAST) grant program's Low-Emissions Aviation Technology awards for research into increasing aircraft efficiency. Additionally, FAA supports university research on aircraft efficiency through the ASCENT Aviation Sustainability Center. Argonne National Laboratory released Aeronomie, an aircraft simulation tool used for research on next-generation zero-carbon and low-carbon aircraft.

U.S. Aviation Climate Action Plan. This plan, published by FAA, contains a substantial aircraft and aviation system-level efficiency section, including specific targets, for emission reduction technologies, and RD&D activities that are underway by government and industry. For example, through the Sustainable Flight National Partnership (SFNP), the federal government will work with industry to demonstrate a 30 percent improvement in aircraft efficiency, compared to current best-in-class vehicles. Research and investments under the SFNP include new aircraft propulsion systems, ultra-efficient wings, small-core gas turbines, and new manufacturing techniques to enable rapid production of new more efficient aircraft.

Continuous Lower Energy, Emissions, and Noise (CLEEN). The FAA is working with industry partners through the CLEEN program to accelerate technologies that will reduce fuel consumption via efficiency improvements and decrease emissions from aircraft, while also targeting reductions in aircraft noise. The CLEEN program follows a one-to-one cost sharing approach, through which industry partners match the FAA's investment, allowing the industry partners to expedite integration of these environmentally beneficial technologies into current and future aircraft.

Locomotive Replacement Initiative. FRA's Locomotive Replacement Initiative aims to replace inefficient, heavily polluting locomotives with newer, cleaner, and more efficient ones through the purchase and rehabilitation of older locomotives to cleaner units, assuring the safety of low- and zero-emission locomotive technologies, and supporting the research into these new technologies. FRA funds locomotive replacement projects through the CRISI grant program, which was discussed previously in this document. FRA also created the Locomotive Emissions Comparison Tool to provide users with a standardized approach to estimating emission reductions from locomotive replacement projects.

U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability (DRIVE). This DOE program is a non-binding government-industry partnership to advance automotive and related technology research. The program is a forum for pre-competitive technical information exchange among its partners.

Public information and education. EPA publishes Fuel Economy Labels for all new vehicles including EVs and plug-in hybrids. The Fuel Economy Label includes information on fuel economy, fuel costs, and environmental impacts such as smog and GHG ratings. EPA also publishes the Green Vehicle Guide to help the public find information on vehicles that are more efficient and less polluting, and the Automotive Trends Report, which documents technology trends and GHG emissions for all new LDVs. EPA and DOE maintain the fueleconomy.gov website, which provides fuel economy and emissions data, along with tools such as the Beyond Tailpipe emissions calculator for EVs and plug-in hybrid electric vehicles (PHEVs).

Pollution from California highways has led to policy actions such as the Advanced Clean Cars Standards.

Efficient vehicle Research and Development. DOE supports research into batteries, power electronics and electric motors, and advanced lightweight materials to improve the fuel economy of modern vehicles while maintaining safety and performance. DOE's Vehicle Technologies Office research efforts also address efficiency improvements for non-road transportation modes like rail, marine, and aviation. DOE research is complemented by demonstration and deployment efforts to move these efficiency technologies into the hands of users, largely through a network of more than 75 coalitions within the Clean Cities and Communities network.

OPPORTUNITIES

Continue to set increasingly ambitious GHG emissions and fuel economy standards for vehicles. EPA and NHTSA can continue to drive emissions reductions, innovation, and efficiency improvements by setting stringent, achievable, and aligned GHG emissions and fuel economy standards for light and heavy-duty vehicles.

Implement standards to improve the efficiency of ships. The EPA can continue cooperating with and implementing standards set by the International Maritime Organization to improve the efficiency of U.S. ships.[133]

Continue research into vehicle efficiency. The federal government can continue supporting vehicle efficiency research. Vehicle-level efficiency improvements include a variety of after-market technologies, such as auxiliary power units and improved aerodynamic devices, as well as technologies for new vehicles. Example programs that agencies such as DOE, FAA, and MARAD have supported or continue to support include DOE's SuperTruck program to encourage the development of medium- and heavy-duty trucks and freight systems, FAA's FAST, CLEEN, and ASCENT programs, and MARAD's META program.

Research vehicle computational power efficiency measures. DOE can support research to achieve greater computational efficiency in vehicles. As vehicles become advanced and connected, and include additional consumer accessories, the computational power needed to run them may grow as well and become a significant source of energy demand.[134]

Research into vehicle purchase decisions. An exploration of the factors shaping consumer preferences towards larger vehicle sizes would help build an understanding of these trends and what might lead consumers to purchase more efficient vehicles while still meeting their needs and preferences. Research into vehicle purchase decisions must capture data from individuals belonging to underserved communities.

Incentives to reduce vehicle size. Local governments can implement incentives based on vehicle size, such as variable parking fees and registration and inspection fees, to discourage the purchase of larger vehicles, such as light trucks rather than passenger cars. Smaller vehicles not only have better fuel economy on average, but also are less likely to significantly injure pedestrians and other vulnerable road users in the event of a crash.[135, 136]

Expand outreach and education to broaden awareness and familiarity with efficiency strategies. EPA will continue to provide useful, reliable, trusted information on efficiency strategies to the public, through initiatives like the Green Vehicle Guide, fueleconomy.gov, and the Fuel Economy Label. EPA will consider how to develop more accessible and practical information for consumers, allowing them to better compare EVs to both internal combustion engine vehicles and other EVs. Additionally, EPA will work across agencies to communicate and educate on efficiency strategies.

STATE, LOCAL, AND INDUSTRY EXAMPLES

California's Advanced Clean Cars Standards. Under the federal Clean Air Act, California has set tailpipe emissions standards for GHGs and criteria pollutants for LDVs that are distinct from federal standards. Twelve other states and Washington D.C. have voluntarily adopted the California standards, going beyond the minimum requirements set by the federal Clean Air Act.[137] In 2022 the California Air Resources Board adopted the Advanced Clean Cars II standards, which regulate GHG and criteria pollutant emissions from new LDVs for model year 2026 to 2035. The standards require that all new LDVs sold in the state by 2035 have zero emissions.[138]

California Locomotive Idling Rule. The California Air Resources Board passed a rule in 2023 to reduce emissions from locomotives operating in the state. The rule requires locomotives to limit idling time to 30 minutes and requires locomotives built in 2030 or after to operate in zero-emissions configurations when in California. The California Air Resources Board estimates that the reduced nitrogen oxide and diesel particulate matter emissions will bring an estimated $32 billion in health savings by preventing 3,200 premature deaths and 1,500 emergency room visits and hospitalizations.[139]

Missoula, MT: Idle Reduction Project. The Missoula Rail Link Railyard installed auxiliary power units on eight switcher locomotives and changed the mandatory idling policy to fit daily temperature conditions to save fuel and reduce emissions. The installation of auxiliary power units was partially funded by a 2009 DERA grant from EPA. The project resulted in a 95 percent annual reduction in nitrogen oxide emissions due to idling, an 89 percent annual reduction in particulate matter 10 emissions due to idling, and an annual average of $235,964 in fuel savings.

St. Louis, MO: School Bus Idle Reduction Project. The Special School District of St. Louis County installed fuel-operated heaters on 116 buses, virtually the district's entire fleet, to reduce school bus idling time in the winter. The heaters activate automatically when temperatures drop so technicians do not need to start and idle the vehicles on cold mornings and afternoons. The heaters reduce air pollution from idling vehicles and are estimated to save approximately three gallons of diesel fuel per bus per day.

Incentives to reduce vehicle size. Washington, D.C. charges higher vehicle registration fees for larger vehicles.[140] Denver, Colorado, proposed legislation that would implement a vehicle weight fee and use the money collected for pedestrian safety.[141] As discussed previously, smaller vehicles on average have better fuel economy and are significantly less likely to injure pedestrians and other vulnerable road users in the event of a crash.

ACTION AGENDA

The following represent a selection of promising opportunities for reducing emissions through improvements to the energy efficiency of vehicles. The table below summarizes these actions and associated lead sectors.

Private Sector	• Develop, manufacture, and market highly efficient vehicles and vehicle components.
Tribal, State, and Local Governments	• Consider incentives to reduce vehicle size.
Federal Government	• Continue to set fuel economy standards for cars and trucks. • Continue to set vehicle emissions standards for cars and trucks. • Provide grants and research to replace old, inefficient locomotive engines with more efficient and low-emission technology locomotives. • Agree on new stringency levels for the Airplane CO_2 Emissions Certification standard at the International Civil Aviation Organization in 2025 and adopt domestically. • Develop and propose new locomotive emission regulations. Improve efficiency of ships through work with the International Maritime Organization
Research	• Conduct research on improving vehicle efficiency.

4. CONCLUSION

Moving toward net zero transportation GHG emissions is not only critical to tackling the climate crisis, but the accompanying transformation of passenger and freight mobility systems toward sustainable solutions and technologies will save lives and improve quality of life. This plan describes actions and recommendations within the Efficiency strategy that all levels of government and the nonprofit and private sectors can take to reduce the energy intensity of travel. Carrying out these actions yields multiple co-benefits alongside the Convenience and the Clean strategies, including cost savings, economic growth, air quality and health improvements, and greater accessibility and community opportunities.

Supporting high-quality, low-emission transportation options for passengers and freight, such as transit, rail, and maritime, will encourage travelers and freight carriers to explore more efficient choices. The federal government and its partners will need to build a transportation system that ensures these efficient transportation modes are the most reliable, affordable, and convenient solutions. Concurrently, facilitating improvements in the operation of passenger and freight transportation systems and the energy efficiency of vehicles will reduce the energy intensity of each mile traveled, regardless of the type of vehicle used.

To decarbonize the transportation sector by 2050, the federal agencies and state, local, and private sector partners will need to take immediate action and continue building on these actions in the long-term. Before 2030, the focus will be on maximizing the impact of the historic BIL and IRA investments and catalyzing collaboration and private investments. Over the subsequent decade, between 2030 and 2040, the federal government and partners will need to adapt strategies and implementation plans in response to global events, consumer response, and technology progress. Finally, by 2050 the federal government and partners must ensure that no one is left behind while achieving a net-zero-emissions economy. Below is a summary of actions described in this document along with key metrics to track and measure progress towards these goals. While some of these metrics can be aggregated to track progress at the national level, others are more appropriate for local communities to consider.

USDOT, DOE, EPA, and HUD continue to collaborate to decarbonize transportation and implement the Efficiency-related programs, initiatives, and actions laid out in this plan. Each agency has access to a unique set of tools, knowledge, and partnerships that can be leveraged to support regional, state, local, and Tribal governments in facilitating a shift toward more efficient travel. Decarbonizing the transportation system will not come without challenges. However, these challenges can be addressed through coordinated, bold actions across the federal government and with state, local, Tribal, nonprofit, and private sector partners

Actions	Key Metrics
• Improve reliability, frequency, accessibility, and affordability and expand service for public transportation to provide options to use more energy-efficient forms of transportation. • Provide incentives to support greater use of efficient travel modes and vehicles.	• Commute Mode Share • Transit ridership data
• Improve reliability, frequency, accessibility, and affordability and expand service for intercity rail to provide options use more energy-efficient forms of transportation for long-distance travel.	• Intercity Passenger Rail Service Quality and Performance
• Expand options for and viability of more efficient freight transportation modes, such as rail or maritime.	• Freight Movement by Mode
• Improve the operational efficiency of transportation systems.	• U.S. National VMT per capita • Energy Intensity of Freight Transportation • Energy Intensity of Passenger Transportation
• Continue to strengthen standards that improve vehicle efficiency and/or reduce emissions.	• NHTSA CAFE and EPA GHG Standards • Average Fuel Economy of U.S. LDVs in Use • Estimated Fuel Economy by Vehicle Type

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