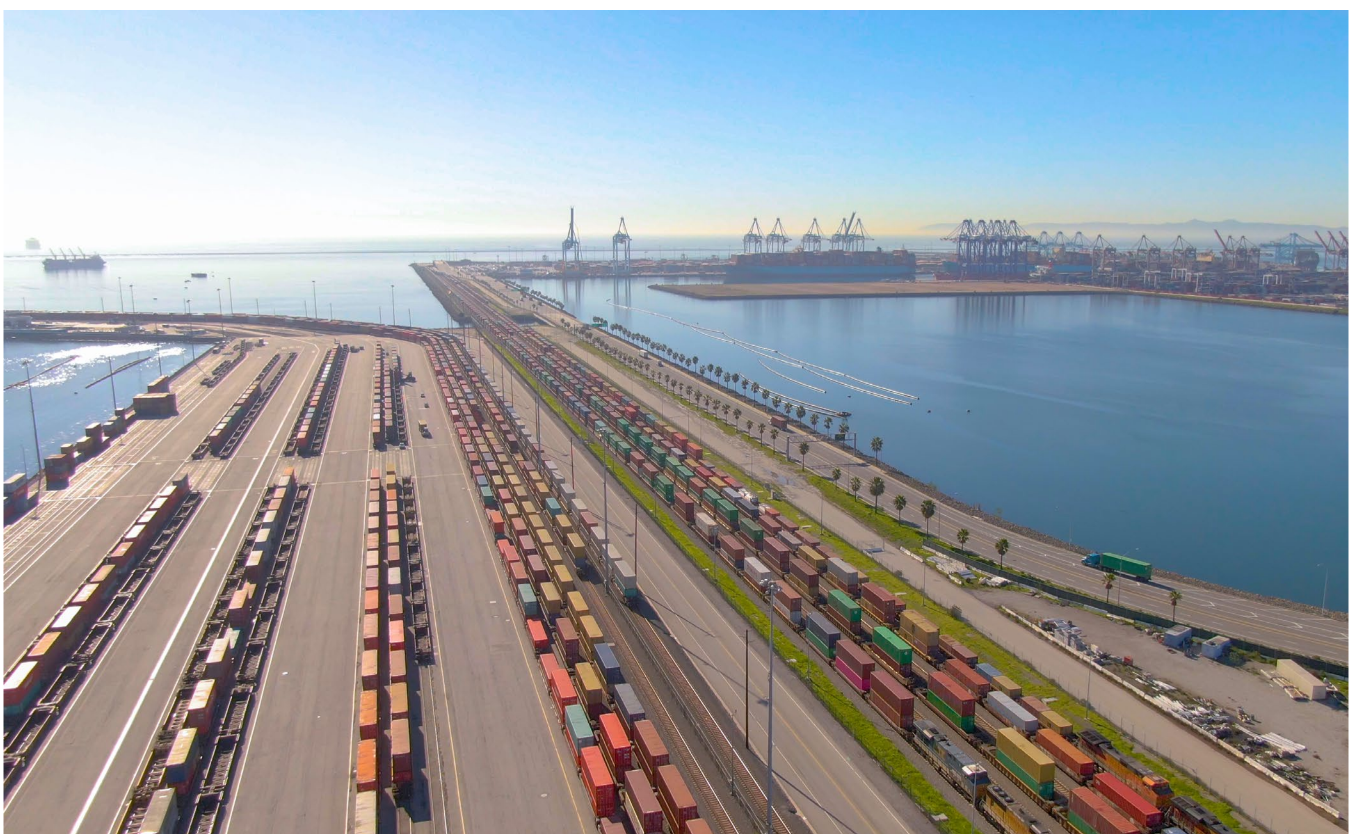
# AN ACTION PLAN FOR RAIL ENERGY AND EMISSIONS INNOVATION

December 2024

# DISCLAIMER





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# 1. EXECUTIVE SUMMARY

## 1.1 Intent and Purpose

The *Action Plan for Rail Energy and Emissions Innovation* proposes actions to reduce and nearly eliminate emissions in the U.S. rail sector, in line with the U.S. economy-wide goal of net-zero greenhouse gas (GHG) emissions by 2050. It also proposes actions to leverage the rail system to reduce emissions from other modes. The national goal of achieving a zero-emission freight system by 2050 draws our attention to the fact that freight transport cannot be addressed simply mode by mode, but it should instead be treated as an interdependent system. This is especially true when pursuing decarbonization. This action plan presents how both rail transport and decarbonization intersect with our national transportation decarbonization blueprint, the decarbonization of the freight system, and national transmission goals. The intended audience of this report is the stakeholders who will advance rail decarbonization in a just and economical way by propelling the suite of actions listed here. This includes government at all levels, rail companies, locomotive manufacturers, labor unions, Amtrak, and more.

The transportation sector is the largest source of GHG emissions in the United States, contributing to the climate crisis that is worsening the quality of life in cities, towns, and rural communities throughout America. Emissions from the transportation sector also contribute to poor air quality. These effects disproportionately impact low-income communities. To address the climate crisis, we aim to achieve net-zero GHG emissions from each part of the transportation sector by 2050 and implement a holistic strategy to achieve a future mobility system that is clean, safe, accessible, and equitable, and provides sustainable transportation options for people and goods. The overall goal of this action plan is to describe pathways for the rail sector to reach net-zero GHG emissions by 2050.

In 2023, the U.S. Department of Energy (DOE), the U.S. Department of Transportation, the U.S. Environmental Protection Agency, and the U.S. Department of Housing and Urban Development released the *U.S. National Blueprint for Transportation Decarbonization* (the Blueprint).[1] The Blueprint provides the roadmap to provide better transportation options, expand affordable and accessible options to improve efficiency, and transition to zero-emission locomotives and other types of equipment. This plan is built on five principles emphasized in the Blueprint to address transportation emissions:

1. Initiate bold action
2. Embrace creative solutions across the entire transportation system
3. Ensure safety, equity, and access
4. Increase collaboration
5. Establish U.S. global leadership.

The Rail Decarbonization Action Plan is one of several action plans that cover each part of the transportation sector.[a] The overall goal of this plan is to describe pathways for rail decarbonization to reach net-zero GHG emissions by 2050. The plan also identifies actions to expand access to rail transportation. By leveraging existing commitments, policies, programs, and partnerships while developing new paths forward, the action plan lays out a strategy that will boost the United States' ability to lead in decarbonization efforts. It should be noted that while regulation and policy will likely be required to fully enact these new paths, the

[a] Separately, individual sector action plans are also being developed to address rail, medium- and heavy-duty vehicles, light-duty vehicles, and off-road vehicles. The Aviation Climate Action Plan was previously released, and action plans have also been developed to address the Blueprint's convenience and efficiency strategies.

action plan itself is not a regulatory document. This plan identifies specific actions for each part of the U.S. rail sector, including line-haul freight, short-line and regional freight, rail yard operations, conventional and high-speed intercity passenger rail, and commuter rail.

## 1.2 A Call to Action

Achieving rail decarbonization will require bold actions, strong leadership, and cooperation and commitment from the rail industry. The bold actions described in this plan include:

- Collaboration with industry, communities, subject-matter experts, and other partners to begin feasibility studies and infrastructure plans to **demonstrate catenary and discontinuous catenary** electrification for high-volume rail corridors.
- Immediate engagement with rail yard-adjacent communities to develop a framework for the identification and deployment of **zero-emission solutions in those rail yards**. In addition to deployment of zero-emission locomotives, this includes measures that can be implemented now to reduce emissions, including idle reduction or elimination in rail yards.
- Establishment of a public-private **rail R&D program** to set industry-wide decarbonization milestones, define R&D priorities, coordinate infrastructure planning for catenary electrification, and address technical barriers for emerging hydrogen fuel cell (HFC) and battery electric locomotive technology.


## 1.3 The Rail Sector Today

Spanning 140,000 miles, the U.S. rail network is the largest in the world and a vital component of our transportation system. It is responsible for nearly 30% of goods movement and boasts an intercity passenger-rail service that stretches from coast to coast. Rail currently represents a relatively economical and energy-efficient mode for freight movement on long-distance routes, especially for bulk goods. However, as other modes decarbonize, rail will be under increasing pressure to maintain its carbon-efficiency advantage.

Total 2022 rail sector emissions are estimated at 35.5 million metric tons of carbon dioxide equivalent, or just under 2% of U.S. transportation GHG emissions. The rail sector employs diverse locomotives that vary in application, technology advancement, and utilization. Figure 1 shows the scope of the U.S. locomotive market, which spans mainline, long-haul freight operations, rail yard or "switching" operations, intercity passenger rail, commuter rail, short-line and regional rail services, and industrial rail operations. Over 99% of U.S. freight and intercity passenger locomotives rely on diesel fuel today. This action plan identifies Class I line-haul freight as the highest priority for medium- to long-term GHG emissions reductions; rail yards and short-line and regional rail as a priority for near-term air pollution reductions; and intracity and intercity passenger rail as key links for expanding affordable access to energy-efficient travel modes.[b]

[b] Light-rail and heavy-rail transit systems are electric and thus do not contribute tailpipe GHG emissions.

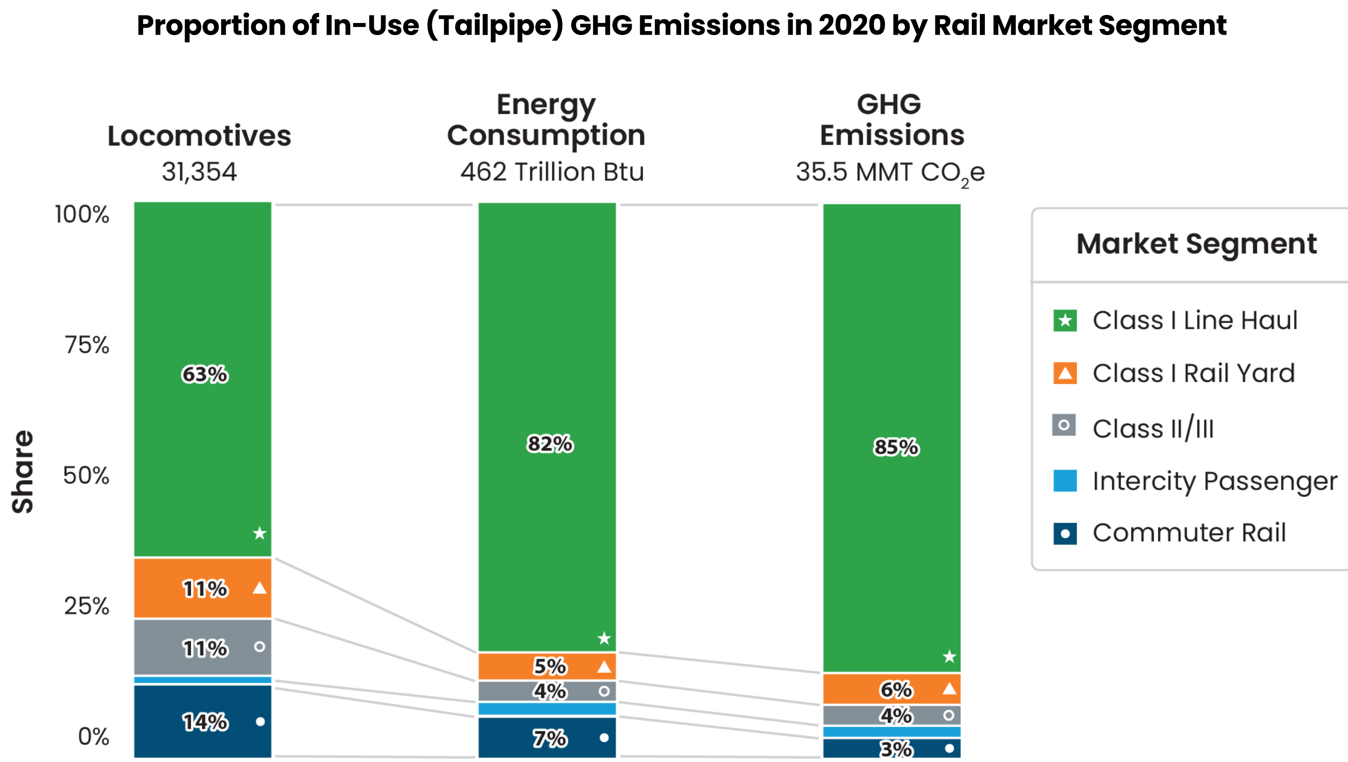



*Figure 1: Proportion of in-use (tailpipe) GHG emissions in 2020 by rail market segment*[2]

**Freight rail.** The six Class I railroads account for around 67% of freight rail mileage, 87% of employees, and 94% of revenue of the freight rail sector. Of rail's total GHG emissions, line-haul operations from the Class I railroads account for 85%. Line-haul operations represent the priority for long-term carbon emissions reductions. Class I rail yard operations, such as moving freight cars between trains, account for 6% of GHG emissions from rail. Emissions from rail yard operations represent a small portion of overall emissions, but they should not be neglected in terms of the negative impact on public health. Approximately 635 short-line and regional railroads (Class II/III railroads) contribute 4% of rail sector GHG emissions. These railroads are critical links to improving freight rail service and reach, expanding options for freight rail by providing connections to mainline railroads for industries, agricultural producers, ports, and other railroads.

**Passenger rail.** Intercity passenger rail in the United States typically operates on freight-owned tracks. Intercity passenger rail is responsible for 1% of the rail sector's GHG emissions. Expanding intercity passenger rail options is a key priority for shifting passenger trips from cars and airplanes to rail. Commuter rail service is operated by 31 transit agencies in the United States for local and regional passenger service and is largely reliant on diesel fuel. Commuter rail systems account for 3% of rail GHG emissions. Expanding and electrifying commuter rail represents opportunities to increase affordable access to clean and efficient passenger rail travel.

## 1.4 Strategy to Decarbonize the Rail Sector for the Future

This action plan explores seven strategies within the rail sector to help achieve the vision of a net-zero GHG transportation system that is safe, affordable, and equitable:

1. Long-term catenary and discontinuous catenary electrification planning
2. Zero-emission rail yards
3. Expanded R&D for hydrogen and battery propulsion rail technologies
4. Expanded access to passenger rail
5. Freight rail system efficiency
6. Rail-to-grid integration (RGI)
7. Efficient utilization of existing assets

### 1. Long-Term Catenary and Discontinuous Catenary Electrification Planning

Rail electrification using overhead catenary systems is a century-old technology that is widely implemented globally and in some parts of the United States. Switzerland's freight and passenger rail network is 100% electrified, India's is 96%, China's is 75%, Russia's is 51%, and the United Kingdom's is 38%. In the United States, Amtrak's Northeast Corridor (NEC) is electrified with catenary, while numerous urban metro, subway, and light-rail systems are fully electric, using either third-rail or catenary systems. A significant advantage of electrified rail is that it allows for passenger rail speeds above 150 miles per hour (mph) and up to 220 mph, though some have reached higher speeds. Preliminary techno-economic studies on select corridors in the United States[3, 4, 5, 6] have identified catenary as a cost-effective and technologically viable approach for certain types of rail operations. Widespread catenary deployment in the United States for freight rail has been limited due to up-front infrastructure cost; the interoperability of locomotives across company, state, and international borders; and the lack of a centrally planned rail network. There are opportunities to reduce the costs of electrification by utilizing catenary in conjunction with battery electric locomotives. Called "discontinuous catenary," or "disco cat," interspersing "islands" of catenary charging infrastructure with sections of the route that use battery power only could potentially reduce total catenary infrastructure requirements by one-third to two-thirds.[7] Between catenary islands, the locomotive draws power from the batteries. While connected to the catenary, the locomotive can recharge the battery and, depending on design, use the electricity from the catenary to directly power the electric traction motors. This also allows for seamless replacement of diesel locomotives with dual-mode battery electric locomotives over time. Diesel locomotives can function similarly to the battery locomotive where catenary is not yet installed. Feasibility studies are needed to determine which corridors to prioritize, the most cost-effective approaches, and resource needs.

### 2. Zero-Emission Rail Yards

Air pollution from locomotives represents a health hazard to the populations living near rail activities, including increased pulmonary diseases and deaths from cardiovascular disease.[8] While rail represents less than 1.1% of transportation GHG emissions, air pollution from diesel locomotives contributed 10.8% of all nitrogen oxide ($NO_x$) emissions and 6.1% of particulate matter ($PM_{2.5}$) emissions from mobile sources in the United States in 2022.[9] Whereas most carbon emissions come from long-distance freight rail, the impacts of criteria air pollutants tend to be most felt in rail-yard-adjacent communities. As such, deployment of zero-emission locomotives (battery electric and hydrogen fuel cell [HFC]) should be prioritized for rail yards. Switcher locomotives in rail yards travel short distances and return to base where they can be charged, making them good candidates for battery electric technology. The Federal Railroad Administration (FRA) awarded grants for battery electric switcher locomotives through the FRA Consolidated Rail Infrastructure and Safety Improvements Program in 2023.

Working in collaboration with organizations representing rail-adjacent communities, analysis for this report ranked rail yards by potential health impacts on nearby communities. The results of this analysis provide data for prioritizing rail yards for zero-emission investments for maximum health impact. Additional factors include finding willing railroad partners, and measuring and monitoring emissions to maximize emissions reductions from diesel equipment operated exclusively in rail yards. The proposed FRA Technology Innovation for Energy-Efficient Railyards (TIEER) Initiative will leverage these data among other factors to help create the nation's first zero-emissions rail yard, in consultation with rail yard owners, operators, and community expert stakeholders.

### 3. Expanded R&D for Hydrogen and Battery Propulsion Rail Technologies

Technologies for fuel cell, battery, and hybrid locomotives are rapidly changing. Establishing public-private partnerships (PPPs) to test locomotives in real-world conditions, to gather locomotive performance data, to understand fueling and power needs, and to access capital for manufacturers and their customers is key to establishing an early market for zero-emissions technologies. It will take a coordinated effort between government, industry, and private funders to accelerate deployment of these emerging technologies. FRA's Office of Research, Data and Innovation has supported the development, testing, and safety deployment of alternative-fueled locomotives as a key part in supporting the rail industry. To further support deployment of these technologies, this plan identifies key R&D areas and the establishment of a **Rail Research and Development Partnership** to be led by DOE, modeled after the successful 21st Century Truck Partnership.

### 4. Expanded Access to Intercity and Intracity Passenger Rail

Expanding intercity passenger rail to new cities and towns, in both urban and rural areas, will provide communities with intercity travel options and greater freedom to choose low-carbon and efficient travel modes. The Bipartisan Infrastructure Law (BIL) invested $66 billion (in advanced appropriations) in our freight and passenger rail network, including billions of dollars to support intercity passenger rail service. That includes $36 billion for FRA's Federal-State Partnership for Intercity Passenger Rail Grant Program to improve, expand, and establish intercity passenger rail and reduce the state of good repair (SGR) backlog. And FRA's Corridor Identification and Development Program, which helps guide intercity passenger rail development, has identified 69 corridors for expanded or improved rail service, including high-speed service.

Within metropolitan areas, investing in light-rail, metros, and subways, all of which run on electricity, is an important rail strategy for reducing transportation GHG by providing Americans with efficient, low-carbon transportation options. The Federal Transit Administration's Capital Investment Grants Program is a funding expansion of public transportation systems across the country. However, it is severely oversubscribed.

For both intercity and intracity passenger rail, facilitating compact, mixed-use development surrounding rail stations is a key strategy for reducing transportation GHG emissions and improving convenience for travelers. Three key planning principles increase access to and encourage the use of rail through land-use development: station location, station connections with other transportation modes, and the use of infill development.

**5. Freight Rail System Energy Efficiency**

In addition to decarbonization technologies to reduce the carbon intensity of rail motive power, overall energy needs for transportation can be reduced by making locomotives more energy efficient and by shifting cargo from less energy-efficient modes to rail. Rail transport is more energy efficient than road transport because there is less friction between steel wheels on steel rails than between rubber tires and asphalt. Trucking tonnage is predicted to increase by 35% by 2040.[10] Expanding access to freight rail through investing in intermodal centers, filling gaps in the network, and improving service can help accommodate projected increases in freight shipments that would otherwise congest highways and increase energy demand.

This plan identifies three pathways to increase overall rail energy efficiency:

1. Support levers to increase train energy efficiency, specifically focusing on strategies that will reduce total energy demands regardless of the powertrain, such as air brake leaks and improved train aerodynamics, without compromising safety.
2. Conduct site-specific analyses to identify levers to reduce bottlenecks at rail terminals and increase throughput on the rail system.
3. Support research to identify locations that would support freight rail transport but lack connective infrastructure.

**6. Rail-to-Grid Integration (RGI)**

A rapid expansion of renewable energy and increased transmission capacity to bring that energy to population centers is critical to meeting the U.S. goal of net-zero-emission electricity generation by 2035. The rail network can support this transition by allowing utilities to site transmission lines along rail corridors while at the same time benefiting from that co-location to power overhead electric catenary for rail propulsion. This plan identifies a set of core research areas to explore potential benefits of and ways to overcome obstacles to coordinated electric grid and rail electrification planning.

**7. Efficient Use of Existing Assets**

Planning and building out the connective infrastructure needed for a zero-emissions rail network will take time. This plan identifies opportunities to reduce emissions while still leveraging the relative efficiency and long lifetimes of existing locomotives. Transitional technologies that can support long-term decarbonization while delivering emissions reductions today include hybrid diesel-electric locomotives, retrofits of locomotives to run on zero-emission propulsion with diesel backup power, and alternative fuels for internal combustion engines, including sustainable liquid fuels and hydrogen. The use of these technologies for rail is expected to increase in the near term and then decrease over time as adoption of electrification and zero-emission technologies increases.

## 1.5 A Rail Sector That Strives for Justice and Equal Access to Benefits

Achieving net-zero emissions by 2050 economy-wide will have many benefits for the U.S. economy and communities—including promoting innovation, maintaining economic competitiveness on the global stage, and reducing the negative impacts of climate change and poor air quality. However, this transformation will require strategic transitions—including changes to locomotives, component manufacturing processes, fuel production processes, and locomotive and infrastructure construction and maintenance. A thoughtful, strategic approach to transitioning the U.S. workforce and communities will be essential to contribute to a transition that strives for justice and equal access to benefits for all Americans.

For some industries, jobs may require workers and businesses to learn new skills or to transition into new roles. Transitioning to a decarbonized rail sector will substantially affect these industries, involving the increased production of and jobs in zero-emission locomotives, component technologies, fuels, and infrastructure, as well as the reduced production of fossil fuels and diesel locomotives. Continued federal leadership is needed to contribute to a transition that benefits all workers and communities, including those that have been historically disadvantaged—through actions such as policies and incentives to support high-quality job creation and retention, as well as ongoing investments in domestic industries and supply chains and programs to facilitate worker training (including reskilling and upskilling).

The main groups that have been disproportionately negatively impacted by rail operations are Tribal Nations and Indigenous peoples, low-income communities near rail operations, and workers in the rail industry that have borne the brunt of the contracting rail sector, often in the form of layoffs. Decarbonization is an opportunity for railroads to create a future that works in tandem with the communities they run through and the workers who keep the trains running. The transition to zero-emission technologies and their accompanying infrastructure presents an opportunity to forge a way forward that both recognizes the past and charts a new path that incorporates consultation with Tribes, workers, and communities near rail operations.

Low-income communities have been and continue to be disproportionately exposed to noise and particulate matter from diesel combustion from rail activities.[11] Air pollution from locomotives is estimated to cause approximately 1,000 premature deaths annually in the United States.[12] Diesel locomotives are a significant source of $NO_x$ and particulate emissions, making rail a priority sector for zero-emissions technology to reduce criteria air pollutant emissions alongside GHGs.

This plan identifies the following key actions to contribute to a just transition to rail decarbonization:

- Fund and support workforce development, training programs, and technical assistance for zero-emission technologies, especially in low-income communities and with existing workers needing reskilling and retraining.
- Collaborate in a meaningful and sustained way with communities and stakeholders on rail decarbonization planning, demonstrations, projects, and infrastructure expansion.
- Ensure that rail decarbonization efforts contribute to the Justice40 Initiative, which sets as a goal that 40% of the overall benefits from certain federal investments flow to low-income communities.
- Ensure that proposed rail projects are evaluated in line with the 2023 Memorandum on Uniform Standards for Tribal Consultation.
- Explore pathways to waive cost-share requirements for rail improvement and decarbonization projects proposed by Tribal Nations and low-income communities.
- Engage Tribal Nations and rail-adjacent communities to identify potential sources of community benefits that could result from rail decarbonization.
- Work in consultation with Tribes and rail-adjacent communities to identify best locations to reroute rail lines, tracks, and/or other infrastructure—such as catenary.

## 1.6 Action Plan for Moving Forward

Key actions of the strategy for rail decarbonization involve leveraging historic amounts of federal funding from BIL and the Inflation Reduction Act to initiate planning for long-term rail electrification, deploy measures to reduce air pollution from locomotives, improve rail system efficiency, and expand access to convenient and affordable transit and passenger rail. This infrastructure planning should leverage the National Zero-Emission Freight Corridor Strategy,[13] which outlines a multiphase electrification infrastructure plan to identify where rail would also benefit. Simultaneously, a near-term research, data collection, and outreach agenda lays the groundwork for long-term electrification infrastructure planning and assessment of the role of hydrogen fuel-cell and battery locomotives in the rail sector. Analysis will also be needed to inform locomotive-to-grid integration potential across different market segments, multimodal freight optimization, and expanding mode-shifting potential. Collectively, these actions compose a strategy to propel the rail sector toward significant line-haul electrification by 2050, reduce air pollution from rail yards as soon as possible, and develop a strategy to provide better options for both freight and passengers that encourage more efficient movement that is also affordable and convenient. Similarly, workforce development and domestic manufacturing capabilities must be bolstered by 2030 in anticipation of long-term electrification infrastructure construction and maintenance.

This plan specifies seven key actions to further each of the seven strategies outlined above and includes specific time-bound milestones to track progress toward decarbonization:

**ACTION 1**

**Initiate detailed feasibility studies for catenary and discontinuous catenary electrification for line-haul freight, intercity passenger, and commuter rail service on high-potential routes.**

- By 2025, initiate study on full costs and benefits of catenary electrification for the priority list of freight corridors identified in this plan, in close collaboration with community expert stakeholders.
- By 2025, finalize short list of rail corridors to conduct detailed feasibility studies—including grid impacts—for long-term catenary electrification planning.
- By 2026, conduct detailed feasibility studies for electrification planning for shortlist of corridors.
- By 2026, develop a national electrification plan that identifies where catenary works, where discontinuous catenary works, and where other solutions may be required.
- By 2027, support advancement of the first discontinuous catenary commuter rail system in the United States.
- By 2027, develop a national railroad workforce plan to ensure that a sufficient workforce is available for installation and maintenance of new catenary and other infrastructure out to 2050 and beyond.
- By 2030, develop a national freight and passenger rail plan identifying necessary infrastructure upgrades, such as grade separations and yards, to achieve modal-shift goals.

## ACTION 2

Support deployment of zero-emission locomotives and idling-reduction measures in rail yard operations to improve public health.

- By 2025, develop a framework for identifying suitable rail yards for full zero-emission transition in collaboration with industry, community partners and experts, and state and local officials.
- By 2030, target deployment of at least 200 zero-emission locomotives in rail yards where they would offer high potential health benefits.

## ACTION 3

Support development and deployment of battery electric and HFC locomotives for line-haul rail operations with a Rail Research and Development public-private partnership.

- By 2025, initiate a Rail Research and Development public-private partnership with industry, community, academic, governmental, international, and other key stakeholders (DOE).
- By 2027, deploy at least 10 battery and/or HFC locomotives in line-haul operations.

## ACTION 4

Expand access to intercity and intracity passenger rail service.

- By 2026, increase transit ridership in the top transit cities back to at least 100% of 2019 levels.[14]
- By 2033, initiate or advance project development of new electrified high-speed rail service on at least two corridors.
- By 2035, initiate intercity passenger rail on at least three new corridors.[15]
- By 2035, eliminate 100% of Amtrak's SGR backlog of Amtrak-owned fleet, Americans with Disabilities Act station compliance, and non-NEC infrastructure.[16]
- By 2035, reduce the Northeast Corridor State of Good Repair backlog by 60% and reduce corridor-wide trip times.[17]
- By 2040, at least double intercity passenger rail ridership from 2019 baseline.[18]

## ACTION 5

**Expand affordable access to freight rail to accommodate projected increases in freight shipments and reduce overall energy requirements in the freight system.**

- By 2026, complete a national assessment of potential mode shift from projected increase in truck and plane tonnage to rail (DOE).
- By 2026, support measures to improve freight train aerodynamics, without compromising safety.

## ACTION 6

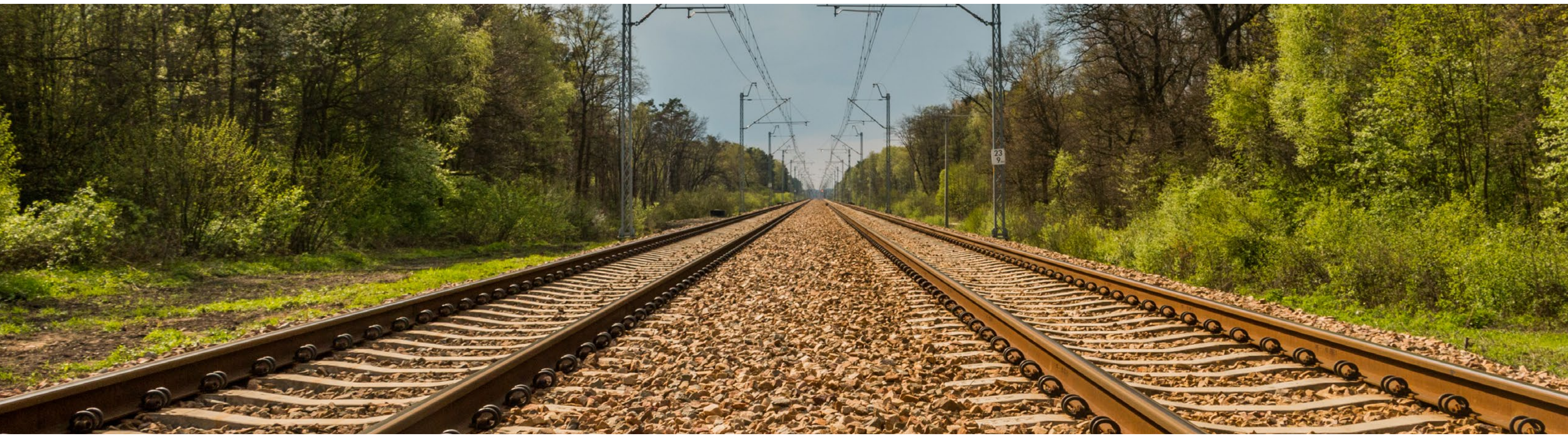
**Rail-to-grid integration: coordinate utilities, railroads, communities, and other stakeholders on rail electrification planning and grid decarbonization and reliability.**

- In 2024–2026, host a series of rail electrification summits that bring together community stakeholder experts, railroads, workers, and utilities to identify challenges and solutions between transmission planning and rail electrification.
- By 2026, complete a national assessment to identify priority corridors for collocating transmission lines and rail right-of-way (DOE).

## ACTION 7

**Leverage existing assets by supporting transitional technologies to reduce near-term emissions.**

- By 2026, support demonstration of diesel-electric locomotive retrofits with battery tenders.
- Until 2035, deploy transitional technology options, where feasible, to reduce emissions from locomotives that still have many years of useful life.



# 2. INTENT AND PURPOSE

The *An Action Plan for Rail Energy and Emissions Innovation* proposes actions to nearly eliminate emissions in the U.S. rail sector, in line with the U.S. economy-wide goal of net-zero greenhouse gas (GHG) emissions by 2050. It also proposes actions to leverage the rail system to reduce emissions from other modes. The national goal of achieving a zero-emissions freight system by 2050 draws our attention to the fact that freight transport cannot be addressed simply mode by mode but must be treated as an interdependent system. This is especially true when pursuing decarbonization. Decarbonization of transportation is similarly linked to impacts on the energy sector both as a consumer of energy and as transmission and transport corridors for energy materials.

This action plan for rail decarbonization presents how rail transport and decarbonization intersect with the *U.S. National Transportation Decarbonization Blueprint* (Blueprint), the decarbonization of the freight system, and national transmission goals. Investing in rail modernization will increase the resilience of our communities, economy, and environment. Reducing harm, expanding access, and returning service to those who have been left behind yield multiple economic, social, and environmental benefits.

This plan is intended to describe pathways for rail decarbonization that advance zero-emission freight, expand passenger rail service, and help deliver increased transmission capacity. It proposes long-term solutions that leverage the currently available solutions of electrification via catenary and discontinuous catenary technologies for emissions reduction. It identifies priority research and demonstrations of emerging zero-emission locomotives and infrastructure, including hydrogen fuel cell (HFC) and battery technologies. Over the near term and midterm, the plan proposes accelerating the adoption of energy-efficiency measures and leveraging investments in expanded access to passenger and freight rail. Lastly, this plan prioritizes actions and strategies where GHG emissions and hazardous air and criteria air pollutants can be reduced or eliminated, especially in overburdened communities near rail operations, Tribal, and rural localities.

Rail decarbonization will be a gradual process, and this plan is a living document. The strategies, supporting actions, and milestones outlined in this plan may be updated based on new research and information.

# 3. BACKGROUND AND CONTEXT

## 3.1 Connection to the U.S. National Transportation Decarbonization Blueprint

The transportation sector is now the largest source of GHG emissions in the United States, contributing to the climate crisis that is negatively impacting the quality of life in cities, towns, and rural communities throughout the United States. Emissions from the transportation sector also significantly contribute to poor air quality that disproportionately impacts communities with environmental justice concerns.

In the Blueprint, the United States committed to decarbonizing the transportation sector by 2050 and addressing impacts from criteria emissions in communities that are most impacted by those criteria emissions.[19] The 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 [CI] of the fuels).

- **Increase convenience** by supporting community design and land-use planning at the local and regional levels that ensure that job centers, shopping, schools, entertainment, and essential services are strategically located near where people live to reduce commute burdens, improve walkability and bikeability, and improve quality of life.
- **Improve efficiency** by expanding affordable, accessible, efficient, and reliable options such as public transportation and rail, along with improving the efficiency of all vehicles.
- **Transition to clean options** by deploying zero-emission vehicles (ZEVs) and fuels for cars, commercial trucks, transit, boats, airplanes, and more.

Rail is the most efficient land-based mode of transporting freight in the United States[20] and one of the most efficient modes of passenger

**Strategies for Transportation Decarbonization**

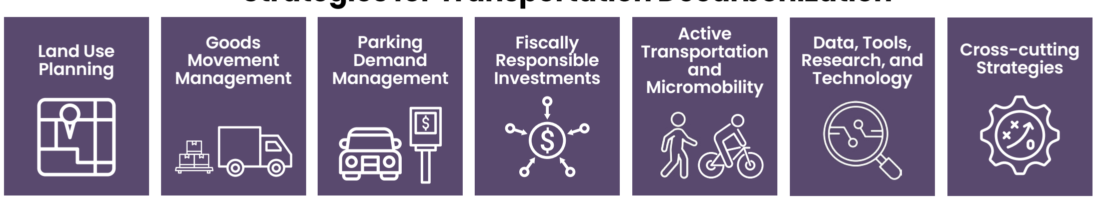



*Figure 2: Strategies for transportation decarbonization*

transportation.[21] To achieve net-zero transportation emissions by 2050, the United States must simultaneously increase its utilization of rail transportation by shifting goods movement to rail from other modes (i.e., "mode shift") and lower the emissions associated with rail usage. This plan builds on the overall strategy presented in the Blueprint to provide concrete actions that set the rail sector on a path to zero emissions by 2050 while addressing air pollution in rail-adjacent communities in the immediate term.

### 3.2 The U.S. Rail Sector

The U.S. rail network is a vital component of our transportation system, responsible for nearly 30% of goods movement and an intercity passenger rail service that stretches from coast to coast. Rail currently represents a relatively economical and energy-efficient mode of freight movement on long-distance routes, especially for bulk goods. However, over 99% of non-transit locomotives operating in the United States rely on diesel fuel. This plan focuses on the strategies and development of solutions to transition existing diesel-electric locomotives to clean technologies, as well as some levers to increase rail efficiency and encourage mode shift from less efficient modes. Other types of equipment are used in rail operations, such as cranes, drayage trucks, and shunters. Decarbonization technologies for these equipment types are the subject of the U.S. Off-Road and Medium- and Heavy-Duty Action Plans. The scope of this plan includes freight and passenger locomotives operating in the rail sector. These locomotives are deployed in Class I, Regional (Class II), and Short-Line (Class III) line-haul and rail yard operations, along with intercity passenger rail, commuter rail, and light-rail and heavy rail, as defined in Table 1. Additional locomotives are used in industrial, mining, and agricultural operations. While the decarbonization strategies presented here may apply to those locomotives, they are not included in the U.S. inventory of rail sector locomotives, and limited data are available for these use cases.

**Table 1: Market Segments in the Rail Sector**

| Market Segment | Definition |
|---|---|
| **Class I Freight** | Railways with annual revenues greater than $943,898,958 |
| **Class II ("Regional") Freight** | Railways with annual revenues between $42,370,575 and $943,898,958 |
| **Class III ("Short-line") Freight** | Railways with annual revenues less than $42,370,575 |
| **Industrial** | Rail service offered by private companies that is not available to the public and is typically used to service a specific site exclusively (e.g., a mine or agricultural production site) |
| **Intercity Passenger** | Rail passenger transportation, except commuter rail passenger transportation |
| **High-Speed Rail** | Dedicated intercity passenger railways that can operate at speeds significantly higher than conventional rail service (typically at least 125 mph) |
| **Commuter Rail** | A transit mode that is an electric- or diesel-propelled railway for urban passenger train service consisting of local short-distance travel operating between a central city and adjacent suburbs |
| **Heavy Rail** | A transit mode that is an electric railway with the capacity for a heavy volume of traffic, characterized by high-speed and rapid-acceleration passenger railcars operating singly or in multi-car trains on fixed rails, with separate rights-of-way (ROWs) from which all other vehicular and foot traffic are excluded, sophisticated signaling, and high platform loading |
| **Light-Rail** | A transit mode that is typically an electric railway with a light-volume traffic capacity compared to heavy rail, characterized by passenger railcars operating singly (or in short trains) on fixed rails in shared or exclusive ROW, low or high platform loading, and vehicle power drawn from an overhead electric line via a trolley or a pantograph |

Trains are four times more efficient than trucks, moving 1 ton of freight over 470 miles on just a single gallon of diesel fuel.[22] Despite handling a third of all intercity freight volume, rail accounts for 2% of all transportation-related GHG emissions. Overall transportation decarbonization strategies may rely on increased use of rail, especially until we achieve widespread adoption of zero-emission trucks. As other modes decarbonize, rail will be under increasing pressure to maintain its carbon-efficiency advantage. Additionally, as trucks transition to zero-emission operations, locomotives are expected to make up an increasing share of criteria air pollution. One analysis conducted by the California Air Resources Board (CARB) demonstrates that trucks became the cleaner mode to transport freight in California in 2023 in terms of criteria air pollutants.[23] Hence, this plan lays out necessary actions to ensure that rail remains a climate-friendly transportation mode as passenger and heavy-duty vehicles are increasingly electrified.[c]

Emissions benefits from decarbonizing rail propulsion sources should be compared against emissions benefits due to mode shift from investments in expanding rail infrastructure. Increasing the share of freight transported by rail or maritime would require these modes to increase their speed, flexibility, or geographic

c See recently finalized light-duty vehicle (LDV) multi-pollutant standards and heavy-duty vehicle (HDV) Phase 3 GHG standards along with compliance pathways for LDV EV sales by 2030 and HDV EV sales by 2030.

reach. Strategies that can increase flexibility and choice of modes that are affordable and meet shipping requirements will be required to enable mode shifts. A system-level treatment of the strategies and actions to support mode shift from on-road modes to micromobility, rail, and maritime modes can be found in the report *Efficient Transportation: An Action Plan for Energy and Emissions Innovation*.

## 3.3 Contributing to a Just Transition

Ensuring a just transition to a decarbonized future is a key priority for all federal transportation sector action plans. The Justice40 Initiative sets as a goal that 40% of the overall benefits of certain federal investments—including investments in climate and environment, health, and economic opportunity—flow to low-income communities burdened by pollution and marginalized by underinvestment, including federally recognized Tribes. The Justice40 Initiative is a key component in federal efforts to confront and address decades of underinvestment, which have contributed to lack of economic opportunity in communities across the country.

In addition to Justice40, executive orders on Tackling the Climate Crisis at Home and Abroad (EO 14008),[24] Worker Organizing and Empowerment (EO 14025),[25] Ensuring the Future is Made in All of America by All of America's Workers (EO 14005),[26] and others prioritize the widespread creation and retention of high-quality jobs with the option to join a union as an integral part of strategies to build an equitable clean-energy future. Key enablers of just and equitable transitions include robust engagement with community and labor stakeholders, as well as formal partnerships and agreements that secure, create, and expand access to good jobs while also delivering community benefits.

The U.S. government (USG) is committed to addressing these challenges through our work across the nation, by increasing safe and affordable transportation options, connecting Americans to good-paying jobs, making communities more resilient, improving access to resources, and enhancing quality of life.

The Just Transition Alliance defines the concept for which the organization is named as "a principle, a process, and a practice. The principle of just transition is that a healthy economy and a clean environment can and should co-exist. The process for achieving this vision should be a fair one that should not cost workers or community residents their health, environment, jobs, or economic assets." The transition to zero-emission technologies and their accompanying infrastructure presents an opportunity to forge a way forward that both recognizes the past and charts a new path that incorporates consultation with Tribes and communities located near rail operations. Decarbonization is an opportunity for railroads to create a future that works in tandem with the communities they run through and the workers who keep the trains running.

The main groups that have historically been—and continue to be—disproportionately negatively impacted by rail operations are Indigenous peoples, low-income communities living near rail operations, and workers in the rail industry that have borne the brunt of an expanding and contracting rail sector, often in the form of layoffs. If carried out in an equitable and just way, rail decarbonization presents an opportunity to redress past harms, eliminate present harms, and prevent future harms of the rail sector on affected communities.

Furthermore, expanding convenient, affordable access to low-carbon passenger rail service will help reconnect communities that have lost rail access over time. This plan identifies opportunities to improve access to rail in rural communities through available programs such as the Federal Railroad Administration's (FRA's) Corridor Identification and Development (Corridor ID) program and other discretionary grant programs.

# 4. RAIL SECTOR EMISSIONS AND ACCOUNTING

This plan uses 2022 tailpipe emissions for the baseline GHG estimates for the rail sector. These emissions correspond to the classification used in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.[27] Total 2022 rail sector emissions are estimated at 35.5 million metric tons of carbon dioxide equivalent (MMT $CO_2e$), or 2% of U.S. transportation GHG emissions (Figure 3). This plan's baseline emissions data represent direct transportation emissions from the use phase of locomotives or "tailpipe" emissions because upstream emissions from electric power, for example, are accounted for elsewhere in the national GHG emissions inventory. Decarbonizing upstream sectors of our economy is the focus of other government-wide initiatives that complement this plan. Many transportation decarbonization solutions rely on electricity directly or indirectly, such as the production of hydrogen from water electrolysis or certain sustainable fuels. Achieving 100% clean electricity by 2035 is a critical co-strategy to support transportation decarbonization.

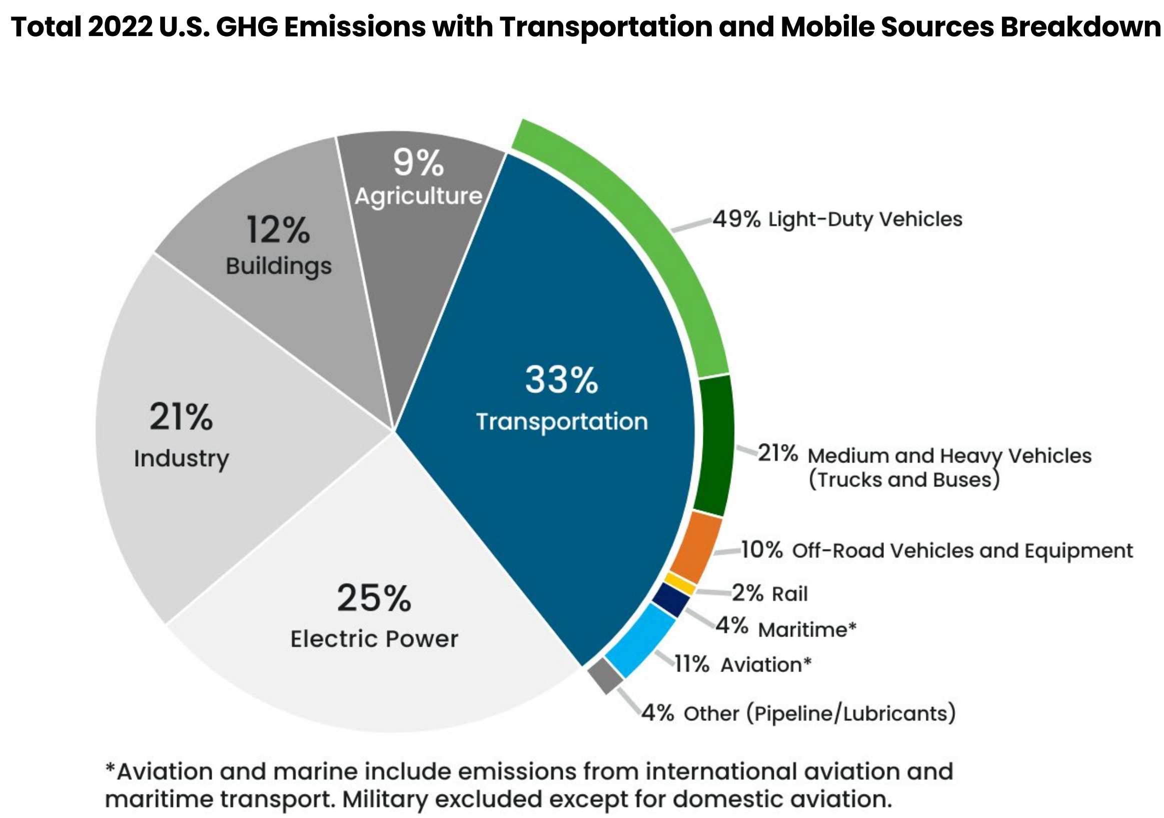



*Figure 3: Total 2022 U.S. GHG emissions with transportation and mobile sources breakdown*[28]

## 4.1 Estimated GHG Emissions by Rail Market Segment

The rail sector encompasses a diverse set of locomotive applications that vary in energy requirements, utilization rates, and technology advancements. Figure 4 displays the proportion of energy use and GHG emissions from each rail market segment. The emissions profiles from each of these market segments identify Class I line-haul freight as the highest priority for medium- to long-term GHG emissions reductions, rail yards, and short-line/regional freight rail (Class II/III) as a priority for near-term air pollution reductions, as well as commuter and intercity passenger rail and key links for expanding sustainable, affordable access to energy-efficient travel modes.

**Class I line-haul.** The six Class I freight railroads are CSX Transportation, Inc. (CSX), Union Pacific (UP), BNSF Railway (BNSF), Canadian Pacific Kansas City (CPKC), Norfolk Southern (NS), and Canadian National Railway (CN). The total freight rail network is about 140,000 miles long. Class I railroads account for around 67% of freight rail mileage, 87% of employees, and 94% of revenue. The 2022 Class I fleet was estimated at 19,837 locomotives.[29] **Of rail's total GHG emissions, line-haul operations from the six Class I freight railroads account for 85%.** Line-haul operations make up most national and international freight and intermodal train traffic. These routes may be over 1,000 miles long. These locomotives travel throughout the United States, Mexico, and Canada and rarely return to the same

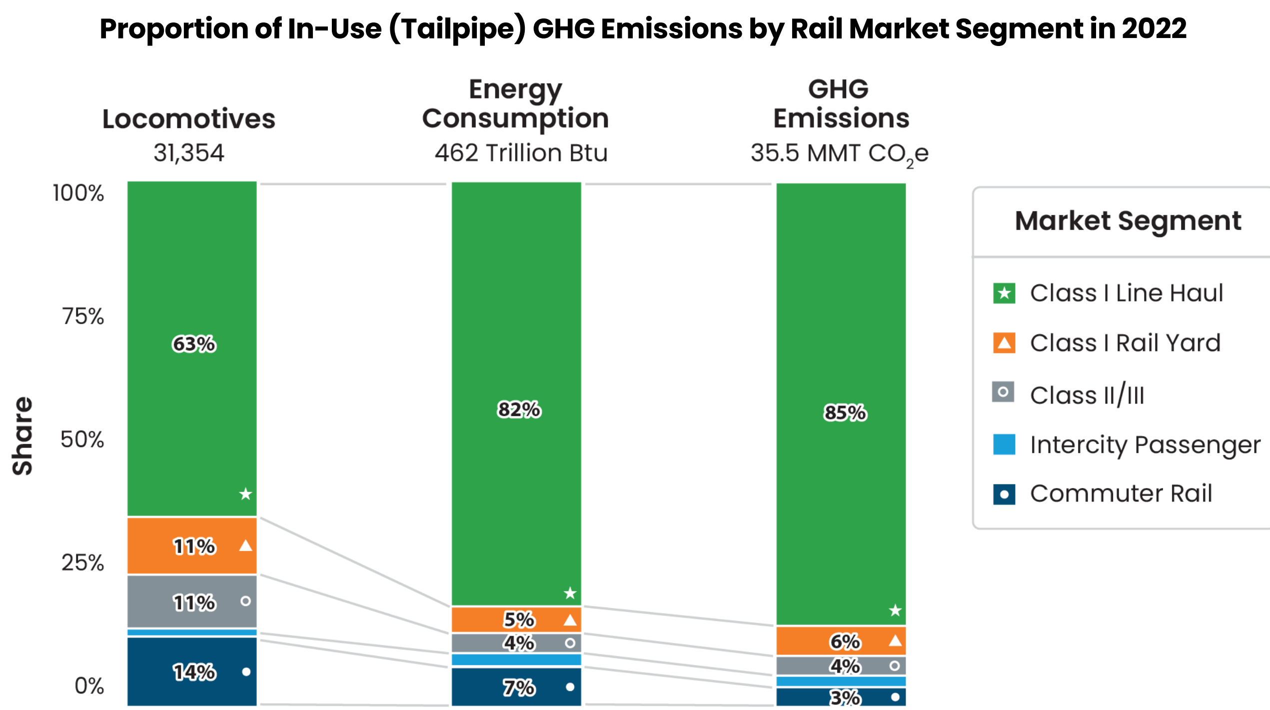



*Figure 4: Proportion of in-use (tailpipe) GHG emissions by rail market segment in 2022*[d]

d Because the Inventory of U.S. Greenhouse Gas Emissions and Sinks does not break out rail emissions by market segment, we rely on the 2022 U.S. EPA National Emissions Inventory to estimate the relative contribution from each rail subsector to overall rail GHG emissions. The NEI uses a bottom-up approach to estimate pollution from the different rail market segments, based on fuel consumption and estimated operating profiles. The NEI is used to distribute total GHG emissions across different rail market segments but does not influence estimated total GHG emissions. The overall emissions from the rail sector were lower in 2022 than in 2019 due to the COVID-19 pandemic, but we rely on the NEI only for the distribution of emissions from different rail subsectors and not total emissions.

place with any consistency. Intermodal trains carry containers or trailers, manifest trains carry a mix of railcars, and unit trains carry bulk commodities such as coal or grain. Line-haul operations represent the main priority for long-term carbon emissions reductions.

**Class I yard.** Switcher locomotives are used to move freight cars (e.g., boxcars, hoppers, tanks) in and around rail yards. **Class I yard operations from approximately 3,349 locomotives account for 6% of GHG emissions from rail**.[30] Railroads typically dedicate the oldest—and therefore most polluting—locomotives for yard operations because these operations have lower power and energy requirements as compared to line-haul operations. Rail yards are often located in population centers near communities that experience environmental injustices. Switcher locomotives tend to operate all hours of the day, emitting criteria air pollutants into nearby communities and generating other negative impacts such as noise, vibrations, bright lights, and traffic congestion. Rail yard operations therefore represent a key priority for near-term criteria air pollutant emissions reductions.

**Short-line and regional freight (Class II/III).** Approximately 635 short-line and regional railroads operate an estimated 3,465 locomotives that contribute **4% of GHG emissions to the rail sector**.[31] These railroads are a critical link to improving freight rail service and reach, keeping freight off the roads by providing connections to mainline railroads for industries, agricultural producers, ports, and other railroads. Short-line and regional railroads also operate some of the oldest locomotives, often running equipment that is retired from the Class I railroads. As the country accelerates its domestic industrial capacity and workforce, publicly owned infrastructure may provide valuable opportunities to pilot new zero-emission technologies and establish models for the implementation and mechanisms of delivering public support to rail operations.

Further deployment of zero-emission locomotives to short-line railroads is a near-term priority for operations in non-attainment areas and near population centers. Continuing access to federal programs for short-line operators to acquire locomotives will be helpful to their adoption of zero-emission locomotive technology.

**Intercity passenger.** Intercity passenger rail in the United States has historically been synonymous with Amtrak, the U.S. federally chartered railroad corporation. Amtrak owns 623 route miles (primarily in the Northeast) and operates, maintains, and dispatches another 229 route miles in Michigan and New York.[32] Most of the remaining 96% of Amtrak's more than 21,400-mile system consists of tracks owned and maintained by freight railroads. Amtrak has 373 locomotives.[33] More than 70% of the miles traveled by Amtrak trains are on tracks owned by other railroads. Recently, the private company Brightline has developed intercity passenger rail service in Florida and is currently building high-speed rail (HSR) service from Southern California to Las Vegas. The Bipartisan Infrastructure Law (BIL), Pub L. No. 117-58 (2021), provided historic levels of funding for improving, creating, and expanding intercity passenger rail. Decarbonizing intercity passenger rail will require sustained, reliable funding for building and improving the country's intercity passenger rail network. **Intercity passenger rail generates 1% of GHG emissions** in the rail sector. Expanding intercity passenger rail is a key priority for shifting passenger trips from cars and airplanes to rail.

**HSR.** New HSR projects will soon create dedicated high-speed passenger rail corridors in California and Nevada. As of 2024, no true HSR projects are in operation yet. As these projects are constructed, they would contribute 0% to GHG emissions. Expanding dedicated intercity high-speed passenger rail is a key priority for shifting passenger trips from cars and airplanes to rail.

**Commuter.** Commuter rail service is operated by 31 transit agencies in the United States for local and regional passenger service, including systems such as Caltrain, Chicago's Metra, and Seattle Sound Transit. Commuter rail service, however, is still largely reliant on diesel fuel. Commuter rail systems operate approximately 4,330 locomotives.[34] Those that still rely on diesel account for 3% of GHG emissions. Expanding and electrifying commuter rail represents priorities for passenger mode shifting to rail.

**Heavy rail** and **light-rail**. Heavy-rail, e.g., metros and subways, and light-rail transit systems are electric. Heavy-rail systems typically use an electrified third rail to provide power for propulsion, while light-rail systems typically use overhead catenary to provide electricity for propulsion. Because they are already electrified, light-rail and heavy-rail operations are not treated in detail in this plan. Since these two modes of rail have been electrified for over a century, these systems offer examples of mature technology that can be of use as the rest of the rail sector decarbonizes.

## 4.2 Minimizing GHGs While Managing Criteria Air Pollutants

An important, related benefit of adopting zero-emissions rail technologies is the reduction in criteria air pollutants, which pose a threat to human health and the environment and are a significant environmental justice concern in communities affected by diesel locomotive emissions. Air pollution from diesel locomotives contributed 10.8% of all nitrogen oxides ($NO_x$) emissions and 6.1% of particulate matter ($PM_{2.5}$) emissions from mobile sources in the United States in 2022.[35] Criteria air pollutants from diesel engines have been proven to have adverse health effects for humans, which is why the Environmental Protection Agency (EPA) regulates certain pollutants from locomotives.[36] Addressing criteria air pollutants from the rail industry is an important concern in reducing the overall negative impacts from the rail industry and is a key component of creating a safer rail network. Additionally, addressing criteria air pollution from the rail sector is necessary to meet federal air quality standards under the Clean Air Act, particularly in nonattainment areas with high levels of diesel locomotive activity.

**Proportion of In-Use (Tailpipe) Criteria Air Pollution by Rail Market Segment in 2020**

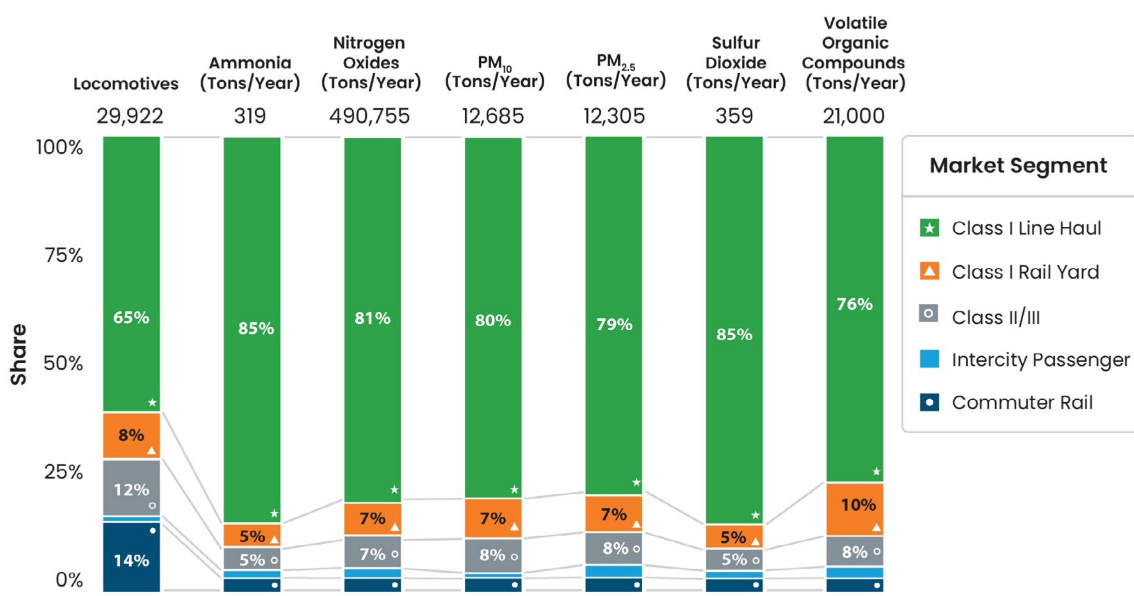



*Figure 5: Proportion of in-use (tailpipe) criteria air pollution by rail market segment in 2022*[37]

**Line-Haul Locomotive Criteria Air Pollutant Emissions Factors by Tier**

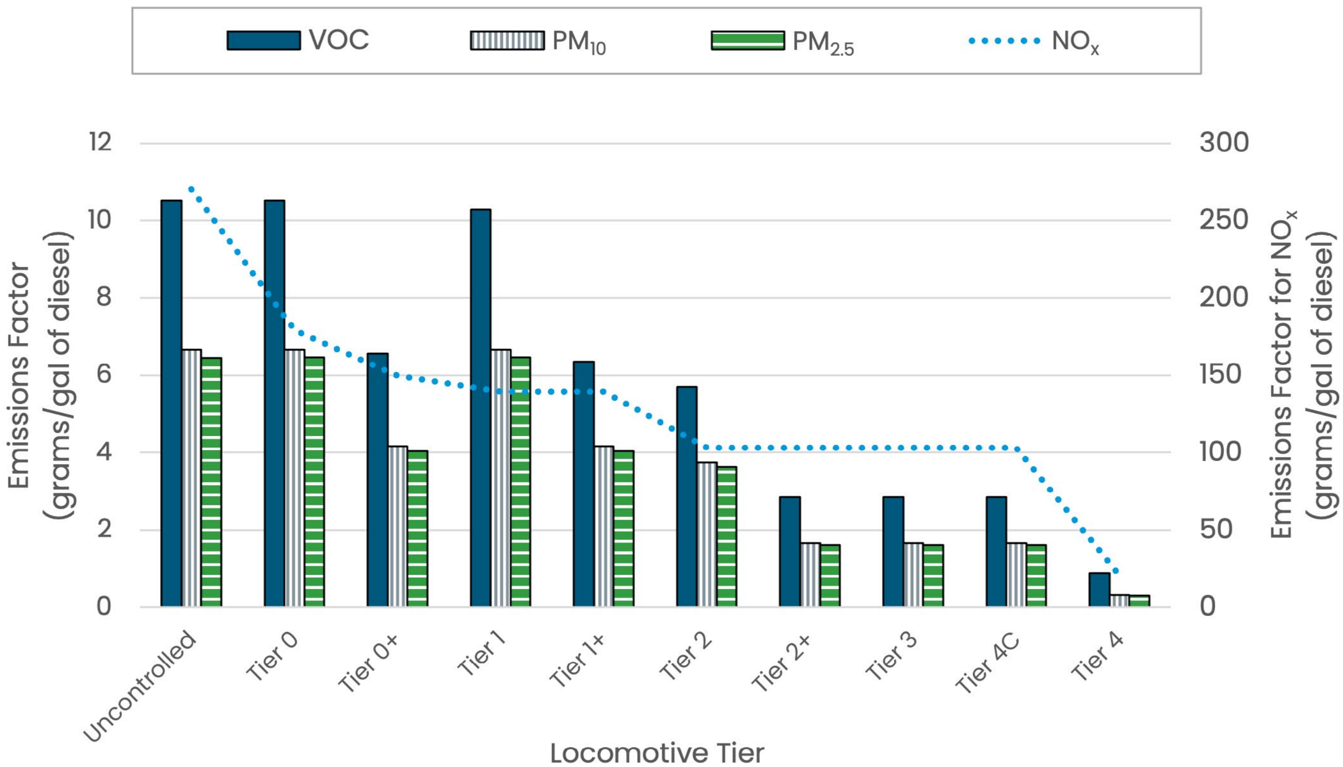



*Figure 6: Line-haul locomotive criteria air pollutant emissions factors by tier*[39]

Criteria air pollutant emissions from locomotives built since 1973 are regulated by the EPA. EPA's regulations include five tiers of emissions standards, which phased in over many years with increasing stringency.[38] EPA's regulations also have requirements for in-service locomotives when they become new again due to extensive maintenance. Figure 6 shows the different emission rates for criteria air pollutants by locomotive tier. The plus sign refers to upgraded or rebuilt locomotives of the same tier, which results in a lower emissions rate.

Adoption of Tier 4 locomotives has been slow, with Tier 4 locomotives accounting for only 6% of the fleet today. Most of the short-line and regional railroad (Class II and III) locomotives are either Tier 0 or pre-Tier 0 (Appendix B Table 10). To date, the EPA has only regulated criteria air pollutants from locomotives. Hence, estimated emission factors for GHGs (methane [$CH_4$], carbon dioxide [$CO_2$], and nitrogen oxides [$N_2O$]) do not vary by locomotive tier. Appendix B, Table 11 provides the best national estimate available for the total quantity of emissions (GHGs and criteria air pollutants) provided by the EPA's 2022 NEI. Some states, such as California and Texas, have completed their own emissions inventories, and other states should be encouraged to do so until nationwide data are available.[40, 41]

## 4.3 Emissions Accounting: Methods and Limitations

To be consistent with the methodology used in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, we do not include life cycle emissions for our baseline estimates for rail sector GHG emissions. However, the total emissions reduction potential of different technology pathways depends on their upstream emissions. For the purposes of this plan, we assume that by 2050, carbon-free electricity and clean hydrogen will be abundant, based on federal and private-sector commitments such as the Clean Hydrogen Shot[42] as well as the national commitment to a carbon-free electricity sector by 2035.[43]

Available data on freight rail assets, and their geographic distribution by rail yard, are incomplete. For example, the short-line and regional railroad (Class II and III) locomotives are counted in the official database only if they interchange with the Class I operations. Thus, some thousands of additional locomotives are expected to be in operation but are not officially counted in the emissions estimates.

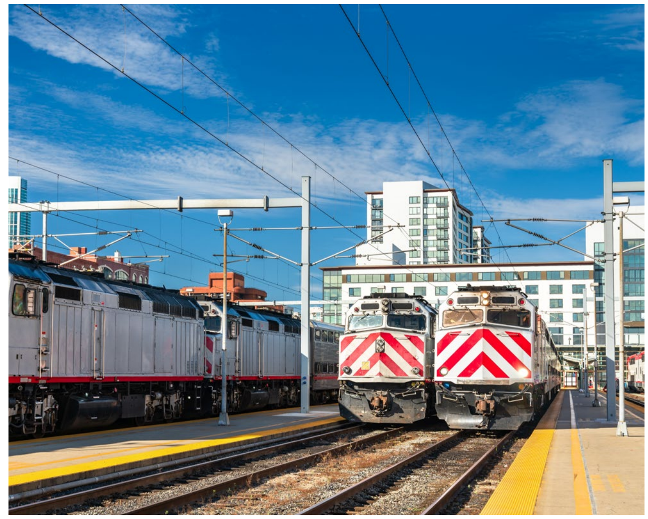
**Accounting for life cycle emissions.**

The data reported in this plan are direct emissions from the use phase of vehicles and transportation systems (i.e., tailpipe emissions). However, the strategies and recommendations in this plan consider full life cycle GHG emissions, including the production and end-of-life phases of vehicles and fuels/energy sources. These life cycle emissions cover GHG emissions from fuel production and processing; vehicle manufacturing and disposal; and construction, maintenance, and disposal of transportation infrastructure. Inclusion of these life cycle emissions is important as the U.S. transportation sector evolves toward new powertrain systems with new fuels/energy sources. The U.S. Department of Energy (DOE) has a long history of using life cycle assessments (LCAs) to assess energy technologies and inform how we can advance these systems and reduce their environmental footprint. For the transportation sector, the Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET®) model is a suite of publicly available, best-in-class models used by the federal government and other stakeholders to assess the energy and environmental impacts of vehicles, fuels, chemicals, and materials across their life cycles. While the GREET model originated with a focus on transportation technologies, GREET currently covers the full life cycle, including manufacturing, industrial, and power-sector impacts.

Reducing and ultimately eliminating life cycle emissions from these sectors is critical to achieving a fully sustainable transportation future and economy-wide decarbonization. While these modal plans are each targeted to a given mode, related strategies and plans are subject to other government-wide initiatives that complement the Transportation Blueprint and these action plans. For example, decarbonizing the electric power sector is identified as a key long-term strategy of the United States.[44] Although outside the scope of this plan, this co-strategy would greatly reduce the emissions associated with energy production that is used to power electric vehicles (EVs) and transportation systems. In summary, these action plans focus on the transportation use phase, but they acknowledge that a whole-of-government approach across multiple sectors and agencies is truly necessary to eliminate nearly all GHG emissions along every phase of the life cycle of the transportation system.

# 5. RAIL DECARBONIZATION STRATEGY

Nearly the entire fleet of freight rail locomotives relies on diesel locomotives combining an electric generator that powers traction motors to drive the axles.[e] A unique attribute of the rail sector, as compared to other modes, is the interoperability of equipment among private companies across the entire North American rail network. This means that the freight rail network can typically carry cargo from Point A to Point B on a single train, even if sections of the network that the train traverses are owned by different railroads. Interoperability is achieved by having nearly uniform equipment (e.g., locomotives) that can interface across the network, including fuel (e.g., diesel). Maintaining interoperability while decarbonizing is a challenge and has led the freight rail industry to look for a single fuel or technology that can decarbonize rail operations without requiring significant investment or changes to current operations. However, different fuels and zero-emissions technologies may be more suitable for different regions or operations. Maintaining interoperability with multiple sources of motive power will require significant changes and cooperation among the entire rail industry, government, and manufacturers. Innovative strategies and technologies, including dual-mode and hybrid locomotives, can help make interoperability a reality in a decarbonized rail sector.



## 5.1 Technology Strategy Overview

This rail decarbonization strategy evaluates four zero-emission technology pathways for long-term decarbonization of freight and passenger locomotives operating in the United States: electrification via overhead catenary system (OCS), electrification via battery electric locomotives (battery locomotives), electrification via a discontinuous catenary system paired with batteries (discontinuous catenary), and hydrogen fuel cell battery electric hybrid locomotives (HFC locomotives). Detailed descriptions of each technology, their most promising use cases, and opportunities to overcome barriers to adoption are described in **Section 5.3**. Additional cross-cutting strategies to support decarbonization, such as workforce development and safety and standards, are discussed in **Section 7**.

Table 2 describes strategies to decarbonize the rail market segments between now and 2035. Key near-term strategies include supporting deployment of battery and hybrid diesel-battery electric locomotives in rail yards, initiating feasibility studies for long-term electrification of high-value corridors, and supporting R&D to test viability of HFC locomotives and battery locomotives for line-haul use. HFC locomotives and battery locomotives (for line-haul applications) are still in the demonstration phase and not yet tested in real-world operating conditions. Deployment of these technologies to collect operational data is a near-term priority. Data from these near-term deployments are critical to refining long-term technology choices.

e Indiana Harbor Belt Railroad intended to convert 31 of its diesel locomotives to compressed natural gas in 2017, but only has four in operation as of 2024.

**Table 2: Near-Term Decarbonization Strategy by Rail Market Segment (2024–2035)**

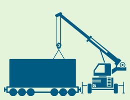
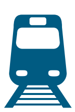
| | | |
|---|---|---|
| **Line-Haul Freight**<br> | **Lay the groundwork for long-term technologies:**<br>• Support measures to improve train energy efficiency, such as improved aerodynamics, without compromising safety.<br>• Support catenary and discontinuous catenary demonstrations.<br>• Encourage build-out of catenary infrastructure.<br>• Begin the long-term planning that widespread electrification would require based on results from detailed techno-economic analysis, in conjunction with long-term electric grid planning.<br>• Support research and demonstrations of battery propulsion technologies for rail.<br>• Support research and demonstrations of HFC propulsion technologies for rail. | **Support immediate deployment of transitional technologies:**<br>• Support use of sustainable liquid fuels.<br>• Support R&D on hydrogen internal combustion ($H_2$ICE) technology and criteria pollution reduction.<br>• Support dual-mode diesel-electric locomotives to provide a bridge technology that reduces some GHG emissions while catenary infrastructure is built out.<br>• Support retrofits of diesel locomotives to support demonstrations of battery and hydrogen tenders. |
| **Short-Line and Regional Freight**<br> | **Lay the groundwork for long-term technologies:**<br>• Support demonstration and deployment of battery locomotives, especially retrofits.<br>• Support demonstration of HFC locomotives. | **Support immediate deployment of transitional technologies:**<br>• Support adoption of idle-reduction measures.<br>• Support deployment of Tier 4 locomotives. |
| **Rail Yards**<br> | **Lay the groundwork for long-term technologies:**<br>• Support discontinuous catenary demonstrations and deployment.<br>• Support deployment of battery locomotives, especially retrofits, and supportive charging infrastructure. | **Support immediate deployment of transitional technologies:**<br>• Support adoption of idle-reduction measures.<br>• Support deployment of hybrid battery-diesel electric locomotives. |
| **Intercity Passenger Rail**<br> | **Lay the groundwork for long-term technologies:**<br>• Expand intercity passenger rail to new communities.<br>• Support catenary electrification feasibility studies, especially for corridors already connected to catenary infrastructure.<br>• Gather performance data on Amtrak's new dual-power diesel-catenary train sets to share lessons learned with the freight rail industry. | **Support immediate deployment of transitional technologies:**<br>• Support use of sustainable liquid fuels.<br>• Support adoption of diesel-electric hybrid locomotives and dual-power diesel-catenary train sets. |
| **High-Speed Rail**<br> | • Support dedicated, electrified high-speed rail service on new corridors. | |
| **Commuter Rail**<br> | • Support feasibility studies for rail corridors best suited for electrification, especially for corridors already connected to catenary infrastructure. | |

**Table 3** describes strategies to decarbonize the rail market segments over the long term. Long-term strategies focus on electrification for a significant portion of the rail network. The long-term role of HFC locomotives cannot be identified with much accuracy until these locomotives have been demonstrated for multiple years in real-world operating conditions. Similarly, the long-term role of battery locomotives operating as stand-alone power or in conjunction with catenary systems will depend, in part, on their demonstrated life cycle performance.

**Table 3: Long-Term Decarbonization Strategies by Rail Market Segment (2035–2050 and Beyond)**

| | |
|---|---|
| **Line-Haul Freight** | • Support measures to improve train energy efficiency, such as improved aerodynamics, without compromising safety.<br>• Encourage wide-scale deployment of catenary (full and discontinuous, depending on rail volumes and grid access) on major ROWs of the rail network.<br>• Support deployment of dual-power catenary locomotives that will ensure interoperability with legacy equipment and catenary infrastructure as it is built out.<br>• Support deployment of HFC locomotives for remote, low-density, long-distance routes, with access to clean hydrogen. |
| **Short-Line and Regional Freight** | • Support catenary deployment on high-density routes that interchange with intermodal network.<br>• Support discontinuous catenary on low-density routes that interchange with intermodal network.<br>• Support battery propulsion technologies (especially retrofits of older locomotives) for operations with <250+ miles daily range that return to base. |
| **Rail Yards** | • Support deployment of discontinuous catenary.<br>• Support deployment of battery propulsion technologies and supportive infrastructure.<br>• Support deployment of HFC propulsion technologies for operations with access to clean hydrogen. |
| **Intercity Passenger Rail** | • Support catenary deployment for routes that operate on high-density freight corridors.<br>• Support dual-mode locomotive deployment on routes that operate on low-density freight corridors. |
| **High-Speed Rail** | • Initiate or advance project development for dedicated, electrified high-speed rail service on at least two new corridors. |
| **Commuter Rail** | • Support catenary deployment for routes with unconstrained ROW.<br>• Support discontinuous catenary deployment on low-density corridors or corridors with constrained ROW. |

*Note: For all rail market segments, encourage the use of sustainable liquid fuels, when available, for hard-to-decarbonize portions of the network and legacy locomotives.*

## 5.2 Current Status of Zero-Emission Rail Technology and Adoption in the United States and Abroad

This section provides an overview of the status of zero-emission technologies available for locomotives in the United States and abroad. Details on each technology, including specific benefits and challenges, and strategies to overcome identified challenges, are provided in **Section 5.3**.

**Table 4** summarizes the role and technological readiness level (TRL) for each technology with potential to help decarbonize the U.S. rail sector. Diesel is the baseline technology against which the other technologies are measured. The table provides a summary of the technology landscape of credible solutions toward rail decarbonization. It shows where individual technologies have strengths and challenges at present. The goal is to inform research, development, demonstrations, deployments, and policy strategies that can be tailored to an individual technology. Clean energy technologies are in a rapid state of flux and this table may change substantially over the next 5 years and should be updated periodically.

**Table 4: Zero-Emission Propulsion Technologies and Their Present-Day Technological Readiness Levels for Each Rail Subsector, Relative to Diesel**

| | Market Segment | | | |
|---|---|---|---|---|
| | Line-haul freight | Rail yard freight | Intercity passenger | Commuter rail |
| **Technology readiness to meet operational requirements** | | | | |
| Diesel | 9 | 9 | 9 | 9 |
| Full Catenary | 9 | 6* | 9 | 9 |
| Discontinuous Catenary (catenary + battery) | 6 | 6 | 9 | 9 |
| Battery Electric | 6 | 9 | 6 | 8 |
| Hydrogen Fuel Cells (HFC) | 6 | 7 | 6 | 8 |
| **Connective infrastructure readiness** | | | | |
| Diesel | a | | | |
| Full Catenary | d | c | d | d |
| Discontinuous Catenary (catenary + battery) | | b | | b |
| Battery Electric | d | b | d | b |
| Hydrogen Fuel Cells (HFC) | d | c | c | c |

**Present-day TRL** to meet operational requirements refers to the present-day ability of each technology pathway to meet current operational needs. TRL is assigned based on global rail operations and not necessarily technology deployed in the United States using the DOE rubric Appendix F – TRL Guide.pdf (energy.gov). Infrastructure readiness and levelized total cost of ownership (TCO) are assessed in the U.S. context.* For yard operations that require loading and unloading of containers, discontinuous catenary or third rail would need to be employed.

**Infrastructure readiness level** describes the state of existing infrastructure into which the technology could be deployed. Dark Green (a): Incumbent technology with end-to-end interoperable infrastructure. Light Green (b): Substantial existing infrastructure or technology that can re-use existing infrastructure. Yellow (c): Gaps in infrastructure but suitable for pre-commercial demonstration. Red (d): Substantial gaps in infrastructure.

**First Third-Rail Electric Locomotive, World Trade Fair, Berlin, 1879**

*Figure 7: First third-rail electric locomotive, World Trade Fair, Berlin, 1879*[47]

The table provides a snapshot of each technology's technical feasibility and infrastructure viability. A technology's overall viability can be described by its infrastructure readiness and its other attributes of how it interacts with the environment. The infrastructure readiness level is meant to describe the present state of existing infrastructure that the technology could be deployed into. We used a binning approach to assess infrastructure readiness level, as described in the table notes. Infrastructure readiness could use further analysis to make it more quantitative, and it should be a future area of research.

A technology's total cost of ownership (TCO) is more difficult to assess because it depends on specifics of the operations and can vary by region in the United States. In general, all technologies are anticipated to be more cost-effective if deployed on a large scale. Because the economics of different solutions vary widely by rail market segment, operating profiles, and geography, we did not assess financial readiness for technology at the market segment level. Rather, we discuss how operating, capital, and maintenance costs compare for different technologies in each of their descriptions in **Section 5.3**.

#### 5.2.1 CATENARY ELECTRIFICATION: AN AFFORDABLE, ENERGY-EFFICIENT, ZERO-EMISSION SOLUTION WORLDWIDE

Catenary electrification involves powering locomotives with electricity via overhead lines. Catenary electrification is a proven strategy to address GHG emissions from rail worldwide, with more than a third of track electrified as of 2018. However, it is not widely deployed in the United States, with less than 1% of track miles electrified. Electricity is the predominant power source for passenger and many freight rail networks in other countries. For example, Switzerland has electrified nearly 100% of its rail network. Russia electrified its Trans-Siberian Railway, the world's longest continuous catenary rail line at 6,000 miles long.[45] India had electrified over 95% of its freight rail network as of April 2024, aiming for 100% by 2025.[46]

**Portion of Rail Networks That Are Electrified with Overhead Catenary Systems OCS or Third Rail by Country**

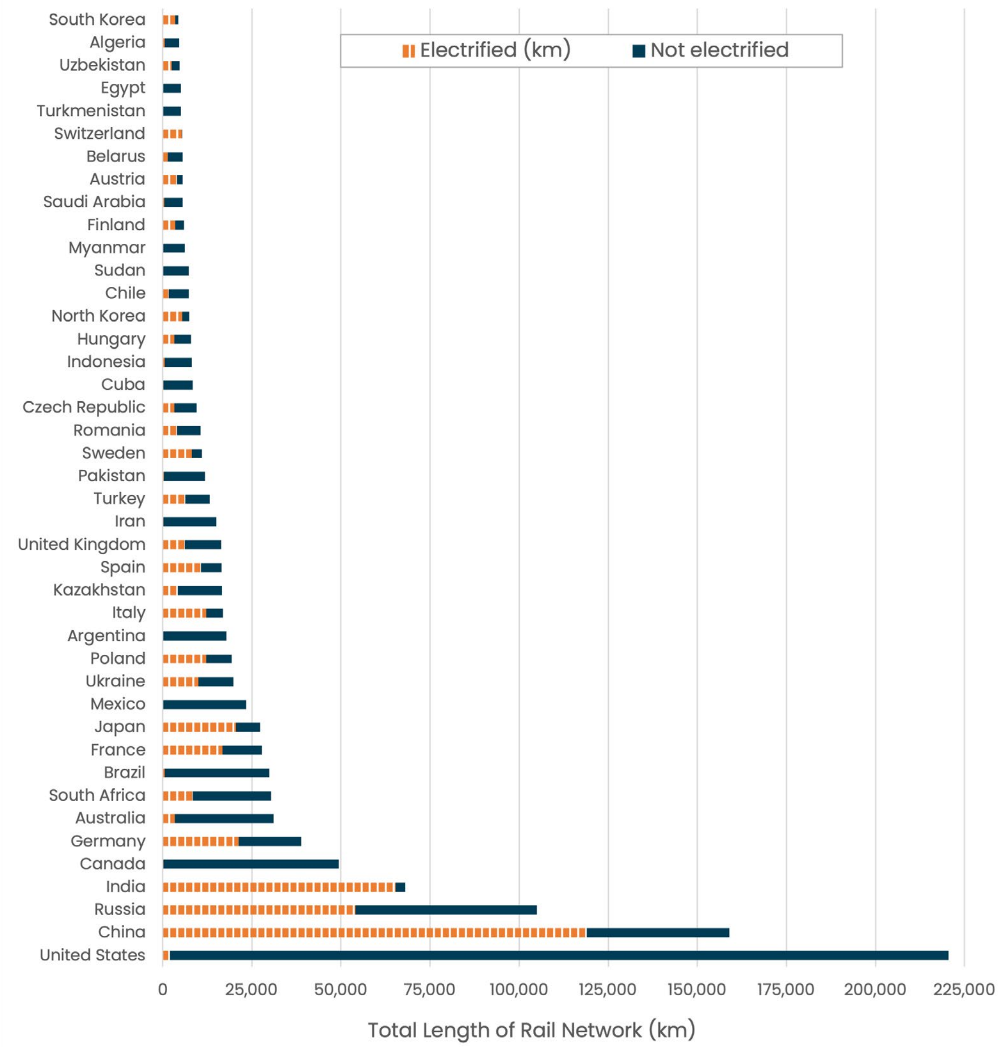



*Figure 8: Portion of rail networks that are electrified with overhead catenary systems (OCS) or third rail by country, for nations with rail networks greater than 4,000 kilometers*[50]

Figure 8 compares electrification of the U.S. rail network to other rail networks around the world with at least 4,000 kilometers (2,485 miles) of track. Today, the United States ranks close to the bottom for the portion of electrified track. In the early 20th century, however, the United States was a world leader in railroad electrification, operating 5,000 electrified track miles in 1931, representing nearly 20% of the world total.[48] However, unprecedented public investment in a national highway system in the post-World War II era pulled much of the existing rail activity—both passenger and freight—to cars and trucks. The original 220,000-mile rail network shrank over time to the 140,000 miles it is now, as railroads abandoned tracks that were less profitable. An FRA-commissioned study in 1983 identified electrification as a viable, profitable approach to improve freight rail service.[49] However, railroads struggled to find investors willing to fund catenary infrastructure for an industry that was rapidly losing market share to trucks.

**Mainline Freight Rail Corridors Proposed for Electrification in a 1983 FRA Rail Electrification Study**

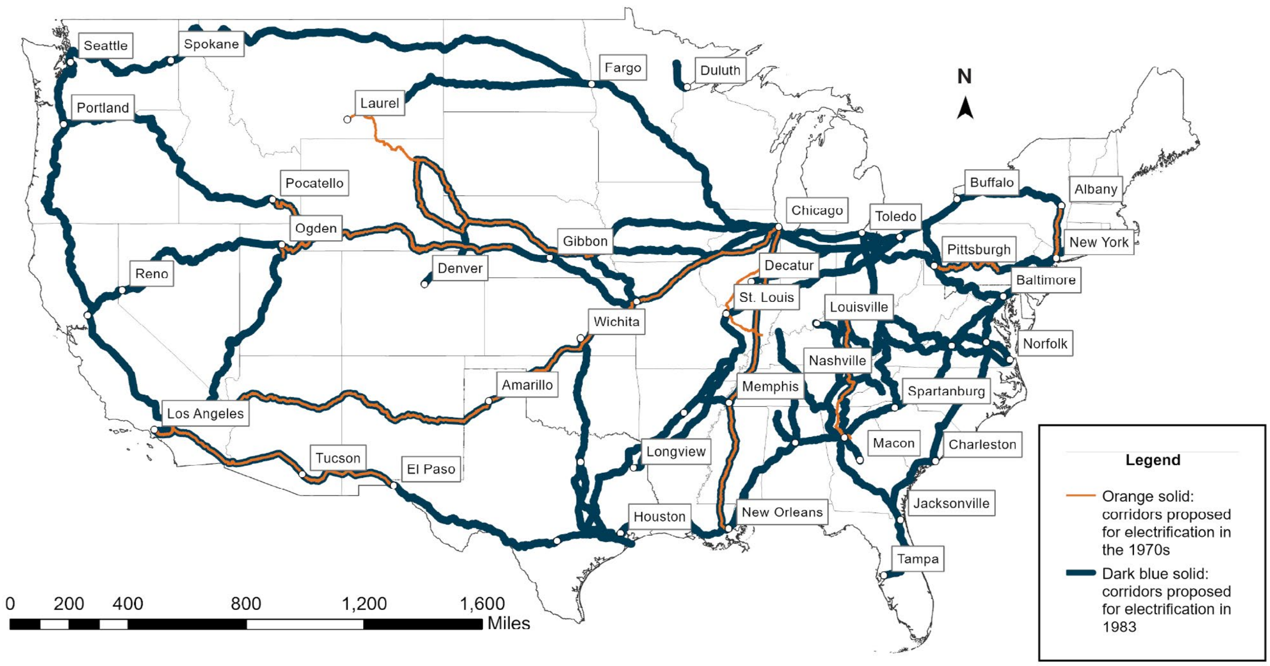



*Figure 9: Mainline freight rail corridors proposed for electrification in a 1983 FRA rail electrification study*[52]

While the expansiveness of the U.S. rail network is often cited as a barrier to electrification, the next three largest rail networks in the world (China at 75% electrified, Russia at 51% electrified, and India at 96% electrified) are majority electrified with overhead catenary, suggesting that size alone is not a major barrier to electrification.[f] Nationalized rail systems are common globally, which affords governments greater involvement and authority in building out and investing in rail networks. The U.S. highway network is primarily publicly owned and largely publicly subsidized through federal and state gas taxes and general funds, whereas the freight rail network is primarily privately owned and generally not directly subsidized. Achieving the decarbonization goals for the entire transport system will require investment in rail infrastructure at a much higher level than in the past, both to expand the rail network and to decarbonize rail operations.

In the early 1900s, a portion of the U.S. freight rail network relied on catenary, especially in places subject to congestion and pollution, such as tunnels.[51] The energy crisis of the early 1970s prompted electrification studies for mainline freight rail corridors (Figure 9).[g] Many of these corridors still transport the greatest amounts of tonnage and represent priority areas for electrification planning.

f While both China's and India's electricity grids still rely largely on coal, India aims to have 50% carbon-free electricity by 2030 and net-zero economy-wide emissions by 2070. See www.iea.org/commentaries/india-s-clean-energy-transition-is-rapidly-underway-benefiting-the-entire-world.

g Several isolated coal-hauling railroads electrified their operations following these studies. Some industrial railroads, such as the Black Mesa and Lake Powell Railroad in Arizona, relied on direct electrification to avoid importing diesel fuel to remote locations.

**Table 5: Existing Rail Corridors with Overhead Catenary Systems in the United States**

| Name | Location | Operation type | Length |
|---|---|---|---|
| Northeast Corridor (NEC) | Washington, DC to Boston, MA | Intercity passenger | 457 miles |
| Keystone Corridor | Philadelphia, PA to Harrisburg, PA | Intercity passenger | 349 miles |
| Metra Electric | Chicago, IL | Commuter | 31.5 miles |
| South Shore Line | Chicago, IL to South Bend, IN | Commuter | 90 miles |
| Denver RTD | Denver, CO | Commuter | 54+ miles |
| Deseret Power Railway | Colorado and Utah | Mining | 39 miles |
| Iowa Traction Railway | Clear Lake, IA to Mason City, IA | Regional freight | 10 miles |
| Caltrain | San Francisco, CA to San Jose, CA | Commuter | 51 miles |

The United States has extensive experience with electrified light and commuter rail services, including the Los Angeles Metro Rail; Seattle Link Light Rail; Houston METRORail; Washington, DC's Metro; Pennsylvania's SEPTA; New York City's Metropolitan Transportation Authority (MTA) subway system; and the Dallas Area Rapid Transit. Currently, the only electrified intercity rail corridors in the United States are Amtrak's Northeast Corridor (NEC) and Amtrak's Keystone Corridor. These corridors represent priority locations for additional analysis to ascertain feasibility of leveraging the existing catenary system to expand electrification of nearby routes. Amtrak plans to study where batteries, hydrogen, and/or catenary offer the greatest feasibility on the remaining non-electrified corridors to meet its 2045 net-zero emissions goal.

### 5.2.2 EMERGING ZERO-EMISSION TECHNOLOGIES RAIL OPERATIONS

**Battery electric locomotives.** Battery locomotives contain electrical energy storage systems on board the locomotive. Battery locomotives have been around for over 100 years, though they did not experience quite the same widespread adoption as catenary. Battery locomotives are being deployed in yard operations in the United States and increasingly widely deployed for commuter rail and intercity passenger rail operations globally. Batteries are also beginning to be deployed for short-haul industrial applications, such as mining, owing to their high regenerative braking capabilities with such heavy loads.[53] They have been demonstrated in line-haul operations in conjunction with diesel locomotives, but are not yet replacing diesel locomotives one to one.

**Battery Locomotive from 1917 in the United Kingdom**


*Figure 10: Battery locomotive from 1917 in the United Kingdom[54]*

BNSF partnered with Wabtec to test FLXDrive™, a 2.4 megawatt-hour (MWh) battery electric locomotive, in combination with two diesel locomotives. The train was used along the Barstow, California, to Stockton, California, route and achieved 11% diesel fuel savings by using energy from regenerative braking to recharge the battery electric locomotives.[55] BNSF concluded after their demonstration with Wabtec that a battery locomotive with a battery capacity of approximately 7.5 MWh could fully replace a diesel locomotive in line-haul service.[56] Further tests are ongoing to provide a path forward for batteries working in tandem with other technologies. Pacific Harbor Line, which serves the Ports of Long Beach and Los Angeles, is testing a Progress Rail Joule SD40JR.[57] Through its FY22 and FY23/24 Consolidated Rail Infrastructure and Safety Improvements (CRISI) Grant Program, FRA funded the purchase or rehab of 35 battery-electric locomotives (mostly for rail yards), indicating the availability of this technology as well as industry desire to purchase zero-emission switcher locomotives.

**Wabtec 2.4 MWh FLXDrive Battery Locomotive**


*Figure 11: Wabtec 2.4 MWh FLXDrive battery locomotive*[58]

**Hydrogen fuel cell battery hybrid (HFC) locomotives.** HFC locomotives have been more widely adopted to date in the passenger rail sector than the freight rail sector, with the major focus being on HFC multiple-unit train sets, which consist of self-propelled passenger cars. Alstom introduced an HFC multiple-unit train set, the Coradia iLint, in 2016.[59] Other companies either are currently manufacturing or have announced the intent to manufacture HFC multiple-unit train sets, including Stadler, Siemens, Talgo, Hitachi, and CRRC. HFC multiple-unit train sets have been demonstrated in several European countries, including Germany, Italy, Spain, Portugal, Austria, and England. CPKC has converted three diesel-electric locomotives to HFC locomotives. CPKC provided CSX with a fuel cell conversion kit to retrofit a diesel locomotive that debuted in 2024.[60]

HFC locomotives are mostly in the prototype deployment phase in the United States, though numerous orders are under contract. Sierra Northern Railway, a short-line railroad, is building four HFC locomotives.[61] San Bernardino County Transit Authority in California purchased a Stadler HFC multiple-unit train set that will begin passenger operations in late 2024.[62] California State Transportation Agency and California Department of Transportation agreed to purchase 10 HFC multiple-unit train sets from Stadler in 2024.[63]

**Discontinuous catenary.** Discontinuous catenary systems use overhead electrified lines along certain segments of the network and alternative propulsion, e.g., battery locomotives, between these electrified sections. Japan Railway Association has been operating a discontinuous battery-catenary system for a section of their passenger rail since 2014. However, no known discontinuous catenary systems are currently in operation for freight. The Utah Copper Company rail line used battery-catenary hybrid locomotives built in 1926.[64] Recent studies from Norway (freight)[65] and the United Kingdom (U.K.) (passenger and freight)[66] found that intermittent catenary is the most cost-effective approach to decarbonize their non-electrified portions of the network. Deutsche Bahn AG, the German national rail company, is constructing an intermittent catenary system in Germany.[67] While these countries have smaller rail networks

than the United States and more extensive existing catenary infrastructure, their consistent findings suggest that detailed analysis on the feasibility of discontinuous catenary systems is a high priority for the United States. On the passenger side, NJ TRANSIT and Massachusetts Bay Transit Authority (MBTA) have found that replacing diesel locomotives with battery-catenary compatible locomotives is the most cost-effective way to decarbonize the remaining non-electrified portions of their network.[68]

One proposal for a hybrid catenary-HFC locomotive has been deployed for passenger trains in Europe.

A European Union consortium is developing and testing a new train prototype called FCH$_2$RAIL (Fuel Cell Hybrid PowerPack for Rail Applications) with partners from Belgium, Germany, Spain, and Portugal. The project is a hybrid, bimodal drive system that combines the electrical power supply from a catenary system—when available—with a hybrid power pack consisting of fuel cells and batteries that is independent of the overhead line. The first hybrid passenger trains are operating in Spain and Portugal.

**Tracking deployment of zero-emission locomotives.** CARB's Zero Emission Rail Project Dashboard tracks zero-emission locomotives around the world, including battery, discontinuous catenary or dual-mode battery and catenary, HFC, and dual-mode HFC and catenary locomotives by locomotive type, deployment location, anticipated delivery date, and more. The U.K. Railway Industry Association found that—in contrast to catenary—battery and hydrogen locomotives with current technology are only practical for light-density routes and yard/industrial switching operations.[69] However, demonstrations for heavy-duty applications are under contract in many locations around the world.

**Current and Planned Deployment of Emerging Zero-Emission Technologies for Locomotives**

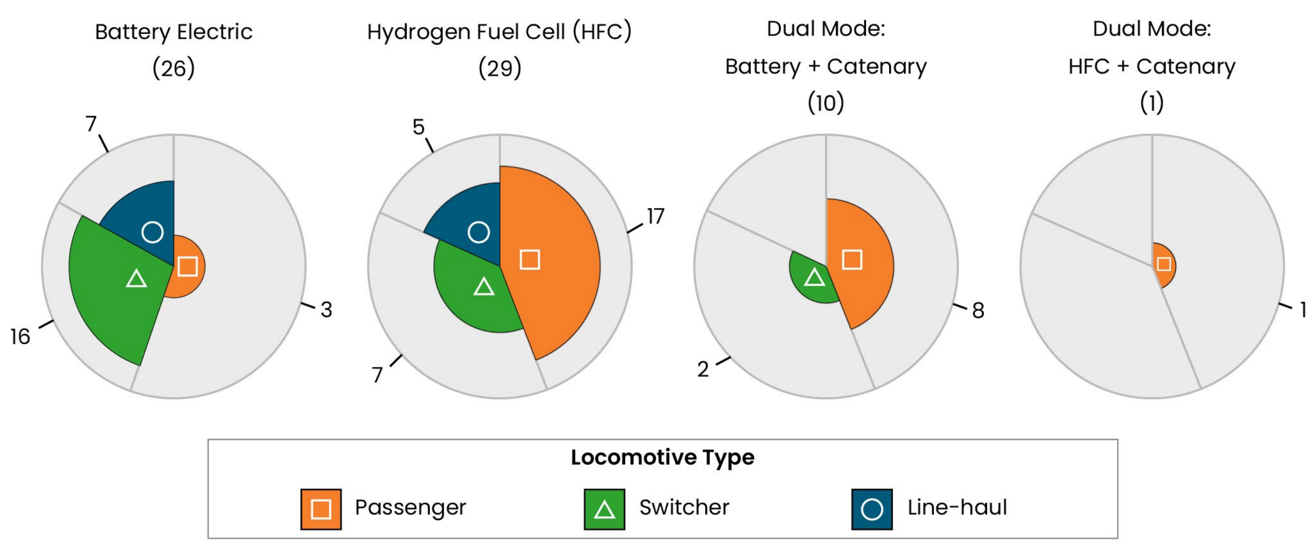



*Figure 12: Current and planned deployment of emerging zero-emission technologies for locomotives*

## 5.3 Primary Clean Technology Pathways

This section describes the benefits, limitations, and applicable market segments for each of the four clean technologies. It also explores opportunities to overcome the known barriers to adoption of each technology in the rail sector. Locomotives in the United States already use an electric-drive system, so the barrier to transition to electrified propulsion is lower than in some other modes and is a focus of this plan. Direct electrification via OCS is the only well-established zero-emission technology, and it is the baseline against which all other potential technologies are compared in terms of cost, performance, timeline, and potential co-benefits to other sectors. However, the economics of electrification may not make sense in all cases. The technology and economics of HFCs and batteries are changing quickly, and breakthroughs in either of these technologies could increase their role in a decarbonized rail system in the longer term.

### 5.3.1 ELECTRIFICATION VIA OVERHEAD CATENARY SYSTEM

Direct electrification is the most energy-efficient pathway to decarbonize the rail sector, but the extent to which different subsectors can be directly electrified (versus supplemented with alternative technologies) varies. Catenary is a **globally adopted, off-the-shelf, safe, efficient, reliable** zero-emission technology for line-haul, industrial, intercity passenger, and commuter rail applications. Direct electrification is the only viable long-term solution for long-haul rail operations currently available, but potential constraints on the availability of grid-supplied electricity, catenary placement costs, and geography will influence which parts of the network make the most sense to electrify with catenary. Catenary for line-haul freight may require some operational changes to optimize infrastructure costs, e.g., potentially reducing the length of trains to reduce wayside power infrastructure requirements.

**Most energy efficient.** Electric locomotives are over 90% efficient, greatly exceeding that of alternative technologies (diesel is approximately 40%). The major reason for this is the comparison of efficiency of the diesel engine creating electricity to supply to the traction motors, vs. pulling the electricity directly from the catenary and delivering to the motors.

**Lowest locomotive operating costs.** Cost of "fuel" (electricity) tends to be less than equivalent diesel power. This is because diesel must be converted into electricity to power the train, unlike electricity from the grid. **Operating costs have been estimated to be about 50% of those of diesel.** This lower operating cost makes catenary more and more cost-effective over time. In the 1970s, the American Railway Engineering and Maintenance-of-Way Association found that the total annual operating costs (including electricity) of catenary would be equal to the cost of a diesel propulsion system after 6 years and one-third the cost of a diesel system after 30 years.[70] The most recent nationwide cost-benefit analysis of freight rail electrification was published in 1983, which found that **electrifying a core 29,000-mile subset of the freight rail network would save $5.2 billion per year**, adjusted for 2024 U.S. dollars (USD).[71]

**Lowest locomotive maintenance costs and long service life.** Because they have so many fewer moving parts than diesel locomotives, electric locomotives require minimal maintenance. Maintenance for electric locomotives costs less than that for diesel or hydrogen locomotives, though the overhaul cost is higher. Notably, this means that overall service is increased because electric locomotives spend more time doing work on the tracks than in the shop. As demonstrated by thousands of locomotive-years of data worldwide, electric locomotives do not require maintenance nearly as frequently as diesel locomotives and—unlike battery locomotives—their power does not degrade over time.

**Greatest power potential.** Because an electric locomotive can achieve greater power per unit than a diesel locomotive, this can impact the acceleration of the train. With higher power, the continuous tractive effort will be increased compared to a diesel locomotive, as it is a direct function of power. This increases the acceleration of the train, but it costs more energy to have that quicker acceleration. Additionally, the starting tractive effort of the train will not be impacted by the greater power, as this is more a factor of locomotive weight, which is dictated by infrastructure limits. Today's standard diesel-electric freight locomotives used for line-haul operations are 4,400 horsepower (3.2 megawatts), but U.S. manufacturers have produced electric locomotives up to 10,000 horsepower. Moreover, this high power potential means they can go up steep grades at higher speeds. The electric locomotive will also be less susceptible to degradations of power, due to high altitude and high temperatures.

**Higher speed capability.** The speed limitations of diesel locomotives make achieving speeds greater than 125 mph impossible, due to limited power and prioritizing lower-speed, higher-tractive effort. This creates a barrier to providing world-class passenger rail in the United States, a key goal of the FRA. Electric train sets can achieve speeds above 200 mph, presenting a viable opportunity to deploy higher-speed passenger rail service in the United States.[72] However, the grade and curvature of the existing rail network would need to be evaluated to see if the current network could support such high speeds.

**Potential for increased ridership.** One of the major benefits of electrification is known as the "Sparks Effect," a phenomenon in which passenger ridership experiences a marked increase following electrification due to (1) increased train speed and frequency due to better acceleration, (2) passenger comfort (quieter, smoother ride, no smoke), (3) increased reliability (fewer train breakdowns), and (4) lower equipment operations and maintenance costs, which means passenger railroads can invest in more frequent service. The extent to which passenger ridership would increase solely due to electrification of existing operations remains to be seen in the U.S. context. Caltrain has seen a 17% increase in ridership since electrifying in September 2024, compared to its last month of diesel operations and a 38% increase in ridership compared to October 2023.[73]

**Resilient to extreme temperature and altitude.** Traction performance and range are not impacted by severe heat or cold conditions or altitude, as demonstrated by the 100% catenary electrification of the 5,772-mile Trans-Siberian Railroad in Russia, which sometimes experiences negative 80°F temperatures in the winter.[74] India's catenary network will operate in temperatures expected to reach as high as 168°F.[75] Although temperatures have not been shown to disable a catenary system, it affects the catenary wire tension, and maintenance requirements for such extreme temperatures will vary by climate.[76]

**No refueling or battery charging time.** Unlike hydrogen or battery locomotives, which need to be refilled and recharged, catenary locomotives draw power directly from the grid as they run. This improves utilization of the asset, as the unit does not have to stop to refuel/recharge.

**Electric load can be more distributed than battery storage.** Electric trains, especially in a discontinuous catenary system, can spread the electric load over a greater number of substations, relative to stationary battery charging stations. However, peak power needs for catenary trains will need to be accommodated at highly localized locations. A combination of agency-owned behind-the-meter solar and battery storage facilities can provide an opportunity to substantially reduce operating costs (power) along with upside-revenue potential from power sales to the grid during grid peak-power demand. Assessing the trade-offs between higher peak-power draw on the grid compared to building additional rail-specific energy storage is a key area of research for determining feasible locations for catenary infrastructure.

**Electric multiple units (EMUs) distribute motor power traction along the entire length of the train.** EMUs are trains in which each car has an independent power source (unlike a locomotive, which pulls behind it a long trail of railcars). For passenger rail, the distributed nature of power sources in an EMU improves the speed, acceleration, energy efficiency, and reliability of the train.

### Opportunities to Overcome Barriers to Catenary Deployment in the United States

Table 6 summarizes the key opportunities to support catenary deployment for all rail market segments. Largely, the barriers to catenary electrification are economic and logistical, not technological, and primarily only for the capital costs of infrastructure, **as operating and maintenance costs of locomotives are much lower over time**. The private payback period for the up-front capital cost on high-density routes has been estimated to be approximately 6–10 years.[77, 78, 79] The major barriers to electrifying the rail network involve access to energy, high and somewhat uncertain infrastructure costs, and a potential disruption to interoperability during construction and points of interchange. These barriers have all been overcome in countries with electrified rail, all around the world. Dedicated and coordinated efforts could overcome these challenges to create a world-class electric rail system for freight and passenger services in the United States.

**Table 6: Strategies to Facilitate Catenary Deployment**

| Objective | Relevant market segments | Opportunities to overcome challenge |
|---|---|---|
| **Reduce uncertainty regarding initial capital cost** | All | • Support initial deployment to gather actual cost information.<br>• Deploy at scale on high-volume routes to spread infrastructure costs over many trains.<br>• Adopt international models for cost-control measures.<br>• Develop partnerships with other stakeholders that could share in costs and benefits of rail electrification, e.g., utilities. |
| **Ensure interoperability** | Line-haul | • Deploy dual-power locomotives in regions where locomotives travel to non-electrified territory.<br>• Convert portion of locomotive fleet to captive service.<br>• Prioritize initial infrastructure development at ends of network. |
| **Support transitional use of infrastructure** | Line-haul, intercity | • Deploy dual-power locomotives while catenary infrastructure is being built out. |
| **Support retrofit options** | Line-haul, yard, short-line | • Support R&D on cost-effective retrofit options for existing diesel locomotives. |
| **Minimize environmental and viewshed impacts** | Line-haul, intercity | • Deploy discontinuous catenary and rely on battery power through sensitive locations. |
| **Support efficient use of electric infrastructure** | Line-haul, intercity | • Reduce train length to reduce instantaneous power demand on the grid.<br>• Schedule trains to smooth power demand over time.<br>• Site substations strategically where there could be other uses for them. |
| **Increase resilience to foul weather** | All | • Size catenary infrastructure appropriately to local conditions, taking into account future climate-change projections. |
| **Support flexible catenary options** | Some yard operations, corridors that share freight and passenger service | • Install retractable catenary.<br>• Deploy discontinuous catenary system. |

**Reduce uncertainty regarding initial capital cost.** The cost of electrifying rail varies considerably depending on terrain and local market conditions, such as competition and supply chains. Few catenary projects have been realized in the United States in the past 100 years. Globally, catenary costs are fairly well known, estimated around $1.5–$3 million per mile.[80] The International Brotherhood of Electrical Workers (IBEW) estimates that OCS could be deployed at scale in the United States for around $2 million per mile. However, these estimates do not include the cost of bringing electricity to the rail network, which will vary greatly by geography, power utility, and competing demands for infrastructure. Europe already has multiple sophisticated firms with experience installing catenary systems, existing supply chains, and host railroads familiar with managing such projects.[81] Considerable investment is needed to develop the supply chains, competition, and experience with building catenary in the United States that could match those in Europe, India, or China. The Indian government electrified 24,850 miles of freight and passenger rail track, averaging only $217,000 per mile.[82] While labor and materials costs are significantly higher in the United States, India's rapid, low-cost deployment of catenary infrastructure provides a motivating example. Capital costs are high relative to diesel, but lower operating and maintenance costs of electric locomotives will offset some or all of the required initial investment over time.

One potential way to reduce the capital costs of catenary is by sharing electricity infrastructure between the power and rail sectors. With coordinated knowledge-sharing and a large skilled workforce, the United States can expect to achieve per-track electrification costs that approach those of Europe. Another cost-mitigating strategy is to employ a discontinuous catenary system that uses battery power to avoid electrification of difficult sections of track (described below). While this may reduce the capital costs of the catenary, it will increase the costs of the locomotive assets, both capital and overhaul costs.

**Ensure interoperability.** The current freight rail model allows locomotives to operate interchangeably across company, state, and national borders. If one company transitioned to electric locomotives, it would no longer be able to operate on non-electrified sections. This challenge can be alleviated by employing transitional strategies such as hybrid consists or dual-mode locomotives until catenary infrastructure is complete. Another option to avoid interoperability issues would be to transition a portion of the locomotive into captive service, i.e., keep locomotives in a specific geographic location. Research is needed to assess the opportunities available to adjust freight rail operations to fully leverage catenary electrification.

**Support transitional use of infrastructure.** Full electric rail service cannot begin until the entire route, including ancillary tracks, is electrified. While rail operations can continue with some disruptions during construction of the catenary system, electric locomotives cannot start operation until the entire line is electrified. Catenary construction time varies widely, but India has been able to electrify their rail network at a rate of 10 miles per day, providing a benchmark against which the United States can be measured.[83] Dual-mode locomotives, or trains with two sources of power (e.g., the new Amtrak trains), can play a role during the transition to full-electric. Near-term deployment of dual-mode locomotives and hybrid trains is critical to collect operational performance data and understand the long-term potential for these trains.

**Support efficient use of electric infrastructure.** Catenary systems require periodic substations to provide electricity to the locomotives, the range between which varies greatly depending on power requirements and train frequency. Electrification increases locomotive reliability, speed, throughput, and power, but the capital cost of electrifying the rail network can increase rapidly if additional infrastructure is needed

**Distance From Rail Network to Nearest Transmission Line**

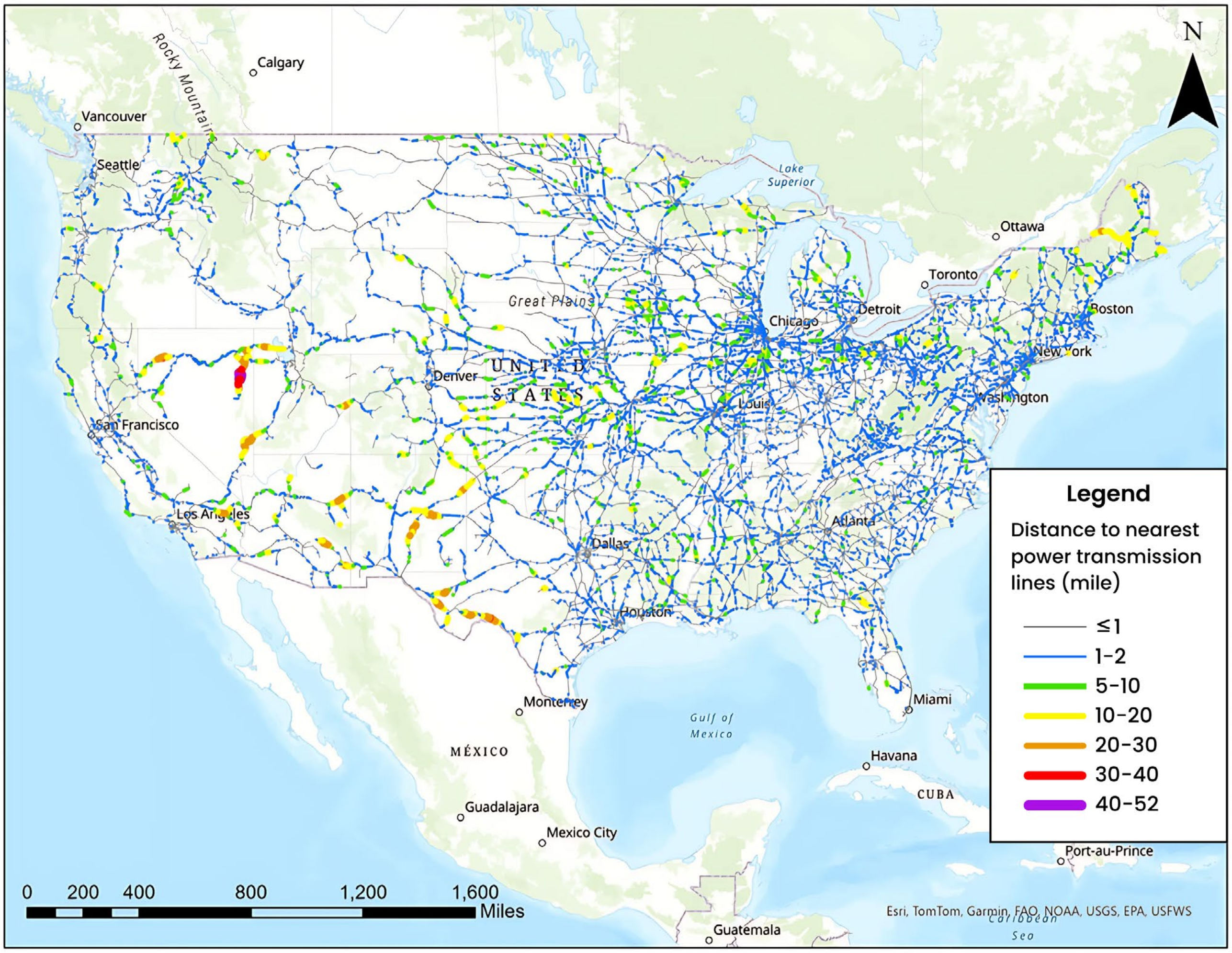



*Figure 13: Distance from rail network to nearest transmission line*[85]

to meet high instantaneous-power demands. Electrification infrastructure costs could be lowered by spreading these power demands over time and space in a more predictable way. For example, breaking one long train into multiple smaller trains will reduce each train's instantaneous power requirements, which could reduce the number and size of substations required along the route. Route-specific research is needed to explore operational adjustments that could ensure reliable power draws.

California's HSR is placing substations every 30 miles, though a typical range would be somewhere between 30 and 60 miles.[84] Depending on terrain, locomotive speeds, and travel volumes, substations could be spaced a bit farther apart to reduce capital costs. Figure 13 shows that the vast majority of the U.S. rail network is within 5 miles of a transmission line, where substations could be connected. Another way to use this infrastructure efficiently is to site substations strategically where there could be other uses for them, e.g., coordinating substation siting with the intermodal hubs identified in the National Zero-Emission Freight Corridor Strategy.

**Support retrofit options.** Whereas diesel-electric locomotives can feasibly be retrofitted to accept a battery or HFC plus tender,[86, 87] it is generally cost-prohibitive to retrofit diesel-electric locomotives to be compatible with a catenary system. This conversion has been tried in India,[88] but ultimately the number of components that need to be changed and rearranged have made new builds a more cost-effective option in the United States thus far. Research is needed to explore options for where retrofits to catenary could make sense.

**Minimize environmental and viewshed impact.** Catenary infrastructure remains even after the train leaves. Construction of catenary equipment may have environmental impacts. The value of the land and the viewshed around rail activities will vary greatly by the communities most affected by the infrastructure. A discontinuous catenary approach lends itself well to mitigating disruptions to the environment and the viewshed, as locomotives could run on battery or HFC power in locations where catenary infrastructure faces opposition from nearby communities.

**Increase resilience to foul weather.** Throughout the United States, foul weather such as hurricanes, tornadoes, and ice storms harm the electric grid today. If parts of the grid go out of service, the rail network will not be able to operate. Also, the foul weather can harm the catenary infrastructure, which will also stop the movement of goods and people until repaired. Climate change may exacerbate the impacts of these weather risks on catenary systems in certain locations. Resilient infrastructure should be built with this in mind.

**Support flexible catenary options.** Overhead catenary cannot generally be used in the portions of rail yards where loading and unloading of containers occurs, because overhead wires get in the way of container loading and unloading from the train. In these cases, a discontinuous catenary system or battery electric locomotives would provide the necessary maneuverability. Retractable catenary technology is being developed and may open greater opportunities for the use of catenary in rail yards, but it has not yet been demonstrated.[89] Vertical clearance can present a challenge for line-haul operations as well, as transit and freight rail operations tend to require different clearance heights. A commonly cited challenge to catenary in the United States is the use of double-stacked containers on freight trains. However, catenary for double-stack freight rail service has been widely deployed in India and has long been operating in Pennsylvania along SEPTA's electrified line.[90] At least two of the BNSF-owned tracks between Los Angeles and Fullerton will be electrified as part of the California High-Speed Rail (CHSR) project, with catenary wire designed to be tall enough for double-stacked container trains to run underneath. UP will operate freight trains on the Caltrain corridor and on the CHSR corridor between Los Angeles and Burbank under the electric catenary wires. Sharing best practices between operations where these solutions are in place will help facilitate deployment in the United States for all rail market segments.

**SEPTA System Operating on Freight Corridor with Double-Stacked Containers**


*Figure 14: SEPTA system operating on freight corridor with double-stacked intermodal containers*[91]

#### 5.3.2 BATTERIES

Battery locomotives contain electrical energy storage systems on board the locomotive. Evolution in battery energy storage systems, coupled with off-grid energy generation, could accelerate the economic and technical feasibility of a battery-based rail network. Notably, batteries will play a role in all four zero-emission technologies, whether catenary, battery-only, discontinuous catenary, or HFC locomotives. Dedicated R&D are needed to ensure that forthcoming battery improvements are relevant to rail needs, particularly in terms of energy density and operational safety.

**Can take advantage of regenerative braking.** Currently, regenerative braking energy is dissipated through heat. With batteries on board, this energy can be captured and reused. Regenerative braking can produce 21%–55% of total energy requirements depending on the route, extending the range for a given battery size or providing power back to the grid via catenary.[92]

**Ongoing research improving technology.** Containerized batteries are modular and offer potential intersectoral use across the power and transport sectors. They can also be replaced with new battery chemistry technologies as they develop in a fast-changing industry. The rail sector can benefit from the significant long-term R&D investments in battery technology for the on-road sector.

**Lower maintenance costs.** Battery locomotives take advantage of the already-electric traction motors on a locomotive and have fewer moving parts than diesel or fuel-cell locomotives. While replacement rates and maintenance requirements of battery locomotives are less understood than catenary locomotives, **maintenance costs are lower than that of diesel or fuel cell** because there is no need to replace filters, fuel injectors, or fluids. Operation and maintenance costs for battery electric locomotives are not available with much certainty, but they have been estimated in the literature at approximately half the maintenance requirements compared to diesel internal combustion engines (ICEs) for on-road vehicles.

**No fundamental operational changes required.** On the one hand, a battery locomotive can be integrated seamlessly into a consist with multiple diesel locomotives, reducing fuel use without changing the operations or range of the train. However, to reduce emissions, these battery locomotives still require charging stations at the route terminus. Battery locomotives can be deployed along existing rail infrastructure and will not disrupt operations for routes in which the locomotives return to a base where they can charge. As more batteries are used in a train, battery locomotives or battery tenders will need to be swapped out with charged ones en route, which could change operations for long-haul routes.

**Opportunities to Overcome Challenges of Batteries**

**Table 7** summarizes key challenges to deployment of battery locomotives and priority strategies to overcome each challenge. Critical barriers for battery electric powertrains include lack of supportive charging infrastructure, low charging rates, low energy density relative to diesel, lack of durability, thermal challenges in extreme operating conditions, and variable electricity cost. Key strategies to support deployment of battery electric locomotives include deploying fast-charging infrastructure, supporting development of battery chemistries that have higher energy density and lower flammability, and developing rail-specific safety standards.

**Table 7: Strategies to Facilitate Battery Electric Locomotive Deployment**

| Objective | Relevant market segments | Actions to support objective |
|---|---|---|
| Increase range | Line-haul, intercity passenger, some short-line operations | • R&D to develop batteries with higher energy densities.<br>• Pair with catenary islands to charge batteries en route (see below).<br>• Reduce the length or payload of trains. |
| Improve performance in extreme temperatures | All to some extent, especially line-haul | • R&D on alternative battery chemistries.<br>• Pair with catenary islands strategically located to reduce wear on batteries. |
| Reduce battery charging times | Line-haul, yard | • Pair with catenary islands to charge batteries en route.<br>• Develop fast-charging standards and infrastructure.<br>• Assess swappable battery models for use in rail sector. |
| Reduce uncertainty in operating and maintenance costs | Line-haul, especially | • Deploy battery locomotives in line-haul operations to collect performance data in real-world conditions.<br>• Facilitate power purchasing agreements for predictable electricity rates. |
| Reduce uncertainty in grid upgrade costs | All | • Conduct detailed corridor-specific feasibility studies to estimate grid impacts of rail electrification.<br>• Strategically site charging infrastructure to leverage infrastructure for other modes. |
| Reduce risk of battery fires and chemical spills in the event of a derailment | All | • Develop robust thermal management packages.<br>• Develop clear safety standards for uses in the rail context.<br>• R&D battery chemistries with lower flammability. |

**Increase range.** Batteries have the lowest energy density of the three zero-emission technologies, with the actual range for line-haul freight not yet demonstrated in real-world operations. Current energy density of batteries used for rail transportation is insufficient to replace existing energy requirements for line-haul and intercity passenger applications, as provided by diesel fuel, without some operational changes and major investments in charging infrastructure. Wabtec's FLXdrive™ heavy-haul battery locomotive has a maximum capacity of 8.5 MWh, compared to about 75 MWh of usable power on a diesel locomotive. Progress Rail's EMD Joule SD70J and SD70J-BB have a maximum capacity of 8 MWh and 14.5 MWh, respectively. While some of the U.S. rail network could support the weight of the eight-axle locomotive, constraints on many portions of the track could limit its widespread use for line-haul freight. Research suggests that battery locomotives could achieve up to a 150-mile range with a 9-MWh battery without considering regenerative braking.[93] However, this range depends greatly on the terrain and the payload. More batteries extend the range of the locomotive but could reduce payload capacity. Depending on the operational model (i.e., swapping charged batteries more frequently or carrying more batteries on the train), the impact of batteries on payload capacity can be great. Fewer batteries mean lower loss of payload capacity but greater time spent stopping to recharge or swap batteries. The relatively high-power and low-energy density lends itself well to short-haul operations with low payloads, such as switching operations and some industrial and short-line operations.

**Improve performance in extreme temperatures.** Battery performance and range decrease in high-heat and severe-cold conditions. For instance, batteries operated in extreme cold for prolonged periods will result in reduced performance and shorter life, thereby requiring replacement sooner than predicted by the original equipment manufacturer (OEM). Improving thermal management will help battery performance.

**Reduce charging times.** Current diesel fueling times are approximately 30–45 minutes. The 2.4-MWh FLXDrive battery locomotive took about 8 hours to charge, while the proposed 8-MWh locomotive should charge in about 4 hours. Fast-charge rates are possible but have higher inverter and charger costs. If batteries cannot be charged at similar rates to diesel locomotives, then swapping discharged batteries for charged ones may reduce the impact on operations. Switching out locomotives to charge takes time and cost (in the form of additional locomotives and engineers). If charging time is required during normal operating hours, then additional locomotives or battery tenders may be required to maintain service quality and frequency for both freight and passenger rail applications. Research is needed to assess (1) the trade-offs between larger batteries or additional battery tenders, and more frequent battery-swapping or dwells at charging stations, and (2) land availability to site supportive infrastructure along rail ROWs.

**Reduce uncertainty in operating and maintenance costs.** While the life cycle of batteries is still improving and varies by battery chemistry, batteries will need to be replaced more often than the life of the locomotive. Typical estimates for battery life range from 10–15 years, depending on how frequently the battery is charged and discharged, the depth to which it is discharged, operating temperatures, and battery chemistry. However, battery locomotives have not yet been operating long enough to observe their actual lifetime. Collecting data on battery lifetime and performance in real-world operations is critical to understanding the long-term role of battery locomotives in the rail sector.

**Reduce uncertainty regarding cost of grid improvements.** To support high-power-demand centralized charging facilities, grid improvements will need to be made. For yard and regional operations and many commuter rail applications, battery charging needs may not present a large new strain on the utility. For widespread line-haul use and/or high utilization rates in the biggest rail yards, major upgrades to the grid may be required. Detailed assessments on a corridor and yard-specific basis will need to be done in coordination with the local utility to ensure sufficient electricity access to maintain rail operations. Infrastructure for batteries depends on the operational model considered and whether the charging stations are grid connected or served by microgrids. Depending on the operational model, additional infrastructure may be required or available by leveraging railroad ROW for transmission lines, either buried or overhead. Currently, there are more questions than answers regarding infrastructure for battery electric locomotives. Systemwide battery-powered locomotives could be achieved at parity with diesel over a 20-year time horizon, if deployed at scale.[94] However, these analyses require operations-level data to validate and provide spatially resolved infrastructure needs. Furthermore, the costs of necessary grid upgrades might be allocated to ratepayers rather than directly to the railroads.

**Reduce risk of hazards of battery fires and chemical spills in the event of a derailment.** Batteries in transportation use have been found to be much safer than the liquid fuels they replace, with much lower rate of fires in EVs than in ICE vehicles. The safety of batteries is highly dependent on thermal management. Risks can be reduced or eliminated with proper thermal management or select rail chemistry (e.g., sodium ion), but federal safety standards must be developed to ensure battery locomotives are not subject to fire risk or chemical spills in the event of a derailment or crash, in the same way diesel fuel is addressed for safety. Due to the nature of rail operation, and the significant energy stored on board a locomotive, off-the-shelf battery systems utilized on road and in stationary applications need to have special packaging considerations to address safety.

### 5.3.3 DISCONTINUOUS CATENARY WITH BATTERIES

There are opportunities to reduce the costs of electrification by utilizing catenary in conjunction with battery electric locomotives, also called “intermittent catenary,” “discontinuous catenary,” or “catenary islands.” Catenary islands refer to the sections of the track with overhead catenary access. Between catenary islands, the locomotive draws power from the batteries. While connected to the catenary, the locomotive can recharge the battery and, depending on design, use the electricity from the catenary to directly power the electric traction motor. This hybrid electrification system reduces the up-front infrastructure requirements for catenary and addresses catenary clearance issues, for example, on bridges and in tunnels. Issues with stationary recharging of battery electric locomotives can be overcome by allowing batteries to be charged en route, dramatically extending the range of the batteries while significantly reducing the up-front infrastructure costs to deliver power to the rail network and reducing operational disruptions to the network. Braking energy could also be recaptured in the batteries, reducing catenary electrical use and need.

Figure 15 provides an illustrative example of how a discontinuous catenary system could work. A mainline freight diesel locomotive in the United States can travel approximately 1,000 miles without refueling. In contrast, a discontinuous catenary system with currently available battery locomotives (approximately 7.2 MWh but would be lower with pantograph on the locomotive) could travel dozens of miles and perhaps up to 200 miles, depending on load and grade. Interspersing catenary islands with battery locomotives along a rail corridor can reduce total catenary infrastructure requirements by one-third to two-thirds, compared to electrifying the entire route with catenary. To maintain some redundancy on the network, as battery energy densities increase, catenary islands could be spaced farther apart, reducing the frequency at which the network would need to connect to the grid. However, larger batteries will require longer sections of catenary to charge, so the total length of the system would be similar, regardless of battery energy density. Detailed route-specific analysis for the entire U.S. rail network is required to assess the optimal spacing and siting of catenary infrastructure that considers impacts on the electricity grid.

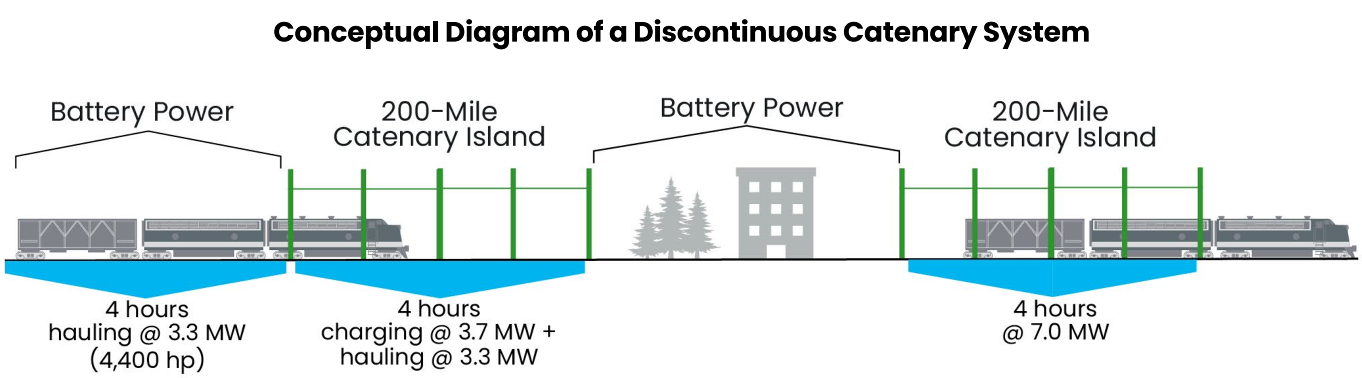



*Figure 15: Conceptual diagram of a discontinuous catenary system*

**Addresses range limitation of batteries and the high up-front costs of catenary.** A discontinuous catenary approach addresses most of the limitations of each technology operating on its own by balancing deployment of each technology with the operational needs and economics of a diverse rail environment. While battery locomotives can be deployed today for yard and short-haul operations, they do not yet have the energy density to achieve current mainline freight needs without significant changes to operations (e.g., swapping charged batteries en route or installing fast-charging stations along the entire route). Leveraging the flexibility and interoperability of battery electric locomotives (including the possibility of retrofitting existing locomotives to use battery tenders in the interim) with the energy efficiency and performance of catenary locomotives reduces the total catenary infrastructure required and reduces (or eliminates) the need for charging stations along routes. Regenerative braking capabilities can also recharge the battery or send power back to the grid through the catenary system.

**Gateway technology to full overhead catenary electrification**. A discontinuous catenary system can support a transition to a full catenary over time by applying sections of catenary on the highest-volume routes. This allows the quickest return on investment, and as technology and installation times improve, more of the route can be electrified, or additional routes could have sections of catenary added. As time progresses, increasing catenary sections on a given route reduces demand for batteries on board.

**Well-established, reliable technology for passenger operations.** The first catenary-battery hybrid locomotives were built over a century ago. Several U.S. and international manufacturers offer catenary-battery hybrid streetcars, light-rail, train sets, and locomotives. U.S. manufacturer Progress Rail is investigating hybrid battery-catenary locomotives for the international market.

**Can integrate with existing equipment.** Unlike a full catenary system, a discontinuous catenary approach can be integrated into existing operations and deployed incrementally during the transition. This incremental phase in would minimize changes and disruptions to current operations. As battery locomotives can operate in consists with existing diesel-electric locomotives, deployment of battery locomotives can begin while catenary infrastructure is still being constructed, reducing emissions in the immediate term.

**Reduces grid upgrades relative to battery-only.** Because the batteries can charge on discrete sections of the network with catenary access, additional battery-charging stations along the network can be reduced or eliminated, depending on the optimal length of catenary sections and range of locomotives operating in battery-only mode.

**High efficiency.** Depending on the percentage of track miles with catenary, a discontinuous catenary system can achieve approximately 80%–85% energy efficiency. Infrastructure can be sited to maximize power needs from catenary and maximize regenerative braking power stored in the batteries, thus reducing total overall electricity requirements compared to battery only.

**Avoids conflicts with lineside stakeholders with concerns over catenary.** Depending on load requirements and improvements in battery energy density, freight trains could potentially travel 50–150 miles on battery power. (Actual ranges must be observed in real-world operating conditions before infrastructure citing decisions are made.) This range enables large portions of the rail network to be left undisturbed by catenary infrastructure. This aspect of a discontinuous catenary approach is especially valuable in locations near sacred sites and densely populated areas and in areas along the rail lines that are severely space constrained, such as tight turns or along riverbanks.

**Among the lowest potential long-term operating costs.** While catenary locomotives have the lowest operating costs, a discontinuous catenary system can reduce maintenance costs of the catenary infrastructure. The extent to which these costs can be reduced needs to be validated based on battery lifetimes in the rail context. The trade-offs between more battery maintenance and less catenary maintenance need to be examined on a corridor-by-corridor basis to fully understand the optimal mix of batteries and catenary for each route.

**Opportunities to Encourage Deployment of Discontinuous Catenary**

The main challenge unique to discontinuous catenary systems is optimizing the locations of catenary islands and the size of onboard batteries to different operational needs. **Supporting the development of corridor-specific modeling efforts** that take into account grid impacts as well as specific operational needs will help identify the most cost-effective locations for catenary infrastructure—or, alternatively, where a single technology may be more cost-effective.

### 5.3.4 HYDROGEN FUEL CELL BATTERY HYBRID (HFC) LOCOMOTIVES

Utilizing hydrogen in a fuel cell to power a locomotive will need to include a battery energy storage system. The battery provides a way to recover energy from braking that can then be used for propulsion power to complement the fuel cell and help optimize the fuel cell loading. Depending on the degree of hybridization, batteries can provide the needed power for higher speeds, heavier loads, traversing of steeper inclines, etc., which helps extend the lifetime of the fuel cell.

The technology readiness for HFC locomotives is not yet at the same level as battery or catenary locomotives, but these locomotives have the potential to play an important role in long-distance, line-haul operations along low-density corridors in the network. There are few industry safety or design standards specific to the use of these technologies in their intended service. To demonstrate commercial viability for HFC locomotives, operational performance and cost data must be shared early on so that the TCO of these technologies can be more accurately estimated.

**Longer range than battery locomotives for mainline freight operations.** Modern diesel locomotives can travel 1,000 or more miles between refueling depending on the operational requirements. Modern diesel locomotives carry 5,000 gallons of fuel, which provides about 70–75 MWh of useful energy after accounting for the efficiencies of the diesel engine and the alternator. While an HFC locomotive cannot store that amount of energy on board the locomotive due to the lower volumetric density of hydrogen compared to diesel, the use of a hydrogen tender could provide sufficient energy storage to match today's diesels in terms of time between refueling. High-pressure compressed gaseous hydrogen ($GH_2$) as well as liquid hydrogen ($LH_2$) are being conceived as possible hydrogen storage options in tenders.[h] FRA found that strategies developed for compressed and liquefied natural gas could be directly applicable to gaseous or $LH_2$ tenders with some modifications.[95] The Association of American Railroads (AAR) is currently developing standards and recommended practices for hydrogen tenders as part of its Interoperable Fuel Tenders for Locomotives (M-1004) standard.

**Potential for fewer required operational changes than battery locomotives, due to shorter fueling time.** Refueling time is critical for many railroad operations, especially long-distance travel. Diesel locomotives carry fuel tanks with a capacity of 5,000 gallons that can be refueled in less than

h HGmotive delivered a 1,300-kilogram (kg) 350-bar $GH_2$ tender in 2023 and plans to develop a 700-bar tender capable of storing up to 4,200 kg of hydrogen ($H_2$). HGmotive also has plans to develop a hydrogen tender that could store up to 6,000 kg of cryo-compressed hydrogen, providing sufficient hydrogen for two locomotives. $LH_2$ is another option for tenders. While slightly less dense than cryo-compressed $H_2$, $LH_2$ tenders will be able to store sufficient $H_2$ on board to meet the locomotive operational expectation of at least one, and possibly two locomotives, depending on the operational requirements. $LH_2$ railcars used by NASA in the 1970s held up to 8,000 kg per railcar.

30 minutes. Standards for dispensing $GH_2$ at flow rates of 60 to 300 g/s (3.6 to 18 kilograms/minute) are being developed for medium- and heavy-duty vehicles;[96] however, these flow rates are far too low for railroad operations. $LH_2$ can be dispensed at much higher flow rates, with the potential to be dispensed at flow rates comparable to diesel on an equivalent energy basis. Wabtec and Linde are currently developing $LH_2$ refueling technology. Refueling times are more than an order of magnitude better than battery electric charging, but more development is required in this space.

**Can be phased in incrementally with existing trains.** Initial deployments can be targeted around yards and multiple unit train sets to provide fundamental learning on optimal infrastructure configurations and operations. As clean hydrogen production scales up, more trains can be phased in to match hydrogen production with demand. Line-haul prototypes can be developed and evaluated on routes with good access to clean hydrogen. One benefit to deploying hydrogen trains is that temporary infrastructure is possible with mobile hydrogen refueling units. A completely interoperable train network will require hydrogen fueling and storage infrastructure throughout the rail network.

### Opportunities to Support Deployment of HFC-Battery Hybrid Locomotives

**Table 8** summarizes the key goals to support HFC locomotive deployment for each rail market segment. Federal studies have concluded that the long-term feasibility of HFC locomotives is still being determined and that significant hurdles must be overcome to see widespread adoption of hydrogen in the rail sector.[97, 98] Key opportunities to overcome these hurdles include, for example, thermal management, robust refueling infrastructure, increased refueling times, and cost reductions.

**Table 8: Strategies to Facilitate HFC Battery Hybrid Locomotive Deployment**

| Objective | Relevant market segments | Actions to support objective |
|---|---|---|
| Reduce risks of hydrogen leakage and fire danger | All, especially line-haul | • Conduct safety tests of HFC locomotives and tenders at federal research facilities.<br>• Develop safety standards for use of hydrogen in rail applications. |
| Reduce uncertainty in capital and maintenance costs | All | • Deploy HFC locomotives in line-haul operations to gather performance and cost data. |
| Support a national hydrogen distribution and delivery network | All | • Support build-out of national hydrogen distribution system. |
| Ensure carbon-free hydrogen is used in rail sector | All | • Support production of off-grid and grid-connected clean hydrogen. |
| Reduce refueling times | Line-haul, intercity passenger, short-lines to some extent | • Develop standards for and test liquid refueling equipment. |
| Encourage responsible usage of scarce renewable energy | All | • Prioritize hydrogen production from excess renewable energy (e.g., instead of curtailing renewable resources). |
| Improve performance in cold weather | All | • Develop refueling standards, e.g., nozzle designs, to address refueling in cold climates. |
| Increase range | Line-haul | • Develop $LH_2$ tenders that can safely transmit fuel to the locomotive. |

**Reduce risks of hydrogen leakage and fire danger.** Hydrogen is a very small molecule, and the risk of hydrogen leaks presents an additional—and understudied—climate risk.[99] Hydrogen is colorless and odorless, so leaks are difficult to detect, and hydrogen fires are invisible during daylight. Significant safety testing must be done to ensure that hydrogen equipment can withstand the real-world operating conditions of the rail sector. Railroads operate through tunnels up to 7.8 miles long,[i] so there are concerns of hydrogen leaking or venting in tunnels, leading to a hazardous condition. Testing these locomotives at federal testing facilities is key to developing standards for their safe use in real-world operating conditions.

**Reduce uncertainty in capital and maintenance costs.** Hydrogen-powered locomotives and passenger train sets are an emerging technology. The capital, operating, and maintenance costs of HFC locomotives and the hydrogen refueling infrastructure are currently unknown. While there have been preliminary studies to estimate the cost of deploying HFC locomotives and the supporting hydrogen refueling infrastructure in the United States, these studies need to be validated against real-world data.[100] Germany's assessment comparing hydrogen, catenary, and discontinuous catenary found that a hydrogen rail system was three times more expensive than a discontinuous catenary with battery approach.[101] Of the six networks studied, battery locomotives were the most economical for three and full catenary for the other three. German rail operator LVNG was the first to deploy large-scale operation of an HFC multiple-unit train set, but they recently announced that they were terminating their operation and converting to battery electric multiple-unit train sets, due to operational challenges in cold temperatures and the high TCO. One region in Austria also dropped plans to convert their diesel trains to hydrogen, after an analysis found that batteries alone could decarbonize the rail network faster than hydrogen passenger trains.[102] Despite the setback, other German rail operators are moving forward with deploying HFC multiple-unit train sets.[103]

The current diesel-refueling infrastructure investment has a large, decentralized physical footprint, and nationwide adoption would require refueling facilities across the network to attain full conversion to hydrogen. The western Class I railroads have large refueling operations in remote locations. They can fuel as much as 500,000 gallons or more of diesel fuel daily. Currently, diesel fuel is delivered to these facilities by pipeline. Diesel fuel is also delivered by railroad tank cars to various refueling locations on the Class I railroads. Today's tank cars can carry up to 34,500 gallons of diesel fuel, which is sufficient to refuel seven locomotives. Hydrogen has a lower volumetric energy density than diesel fuel, and it will require the use of a tender to provide enough hydrogen to enable an HFC locomotive to meet the same operational expectations as a diesel locomotive. Hydrogen tenders add capital, operating, and maintenance costs. Hydrogen refueling infrastructure will be costly compared to diesel infrastructure. Scaling up clean hydrogen production and infrastructure can help provide more certainty on the availability and cost of hydrogen for the sector. Similarly, demonstrating HFC locomotives—particularly in line-haul operations—is key to gathering performance data and assessing long-term operational costs in the U.S. context.

**Support a national hydrogen distribution and delivery network.** Hydrogen is a nascent energy source and needs a national distribution and delivery system like that of the petroleum system. One strength of hydrogen is that it is dispatchable and storable and it can potentially be moved via transportation networks, including rail or via pipeline. However, the infrastructure to do so does not exist. The ability to provide low-cost, low-CI hydrogen at the volumes required for locomotive refueling locations is a major challenge. The

i The longest tunnel currently in operation is the Cascade Tunnel in Washington state on BNSF's tracks.

high costs of transporting and storing hydrogen suggest, for the near term, that hydrogen use in the rail sector may be best suited to locations that have hydrogen production nearby. It is also suited to locomotives that operate on captive sections of the network, i.e., sections where railcars come home to the same location every night and do not travel across state and national boundaries. Future distribution and delivery infrastructure can leverage the historic investments in hydrogen production in the Regional Clean Hydrogen Hubs to form the backbone of a hydrogen network to connect with rail corridors. Storage and distribution network analysis is critical to understand the full costs of HFC locomotives.

**Ensure carbon-free hydrogen is used in the rail sector.** The CI of hydrogen depends on the pathways used to produce it. Today, about 10 million metric tons (MMT) of hydrogen is produced in the United States, mostly for petroleum refining, ammonia, and the chemical industry. About 95% of it is produced from steam reforming of natural gas without carbon capture and storage (CCS). Clean hydrogen produced from electrolysis of water utilizing renewable or nuclear energy is a proven, zero-carbon emission fuel.[104] Hydrogen can also be produced from fossil fuels via thermal pathways, which, when integrated with carbon capture and sequestration, can produce hydrogen with low-to-near-zero CI. When integrated with CCS, the CI can be reduced by 90% or greater,[105] but these results are highly dependent on the fuel source and can be worse than diesel emissions, if using coal plus CCS, for example.[106] The thermal pathway is important to consider in any national strategy because it can deliver low-carbon hydrogen without straining grid resources that might be critical to the decarbonization of other transportation modes. Similar to the present-day electrical grid, urgent investment is needed to expand the availability of clean hydrogen along with high fidelity and trusted LCA tools to make sure clean hydrogen is used in rail.

**Reduce refueling times.** The fueling speed for locomotives is an important consideration. Because the transfer of compressed hydrogen gas requires significant cooling equipment to keep hydrogen at a safe temperature, reaching fueling times on par with diesel is a technical challenge. While $LH_2$ refueling rates may reach parity with diesel fueling rates, fast $LH_2$ refueling rates are still in development. CRRC reported that their mainline hydrogen freight locomotive, which stores 270 kilograms (kg) of $LH_2$ on board, takes 2 hours to fuel the locomotive. A significant percentage of locomotive refueling uses mobile refueling trucks, even at locations with fixed refueling pads. The development of mobile hydrogen refueling trucks is in the early stage of development, and considerable advancements are needed to achieve refueling rates required for hydrogen locomotives. Refueling times for hydrogen must be reduced and liquid tenders developed and tested in operation to make HFC locomotives a viable line-haul option.

**Encourage responsible use of scarce renewable energy.** The round-trip efficiency of electricity used in the train's traction system produced from HFCs consuming hydrogen via the electrolytic pathway is less efficient than direct electrification or a battery electric train consuming the same renewable-electricity inputs. However, the optimal use of renewable electricity resources is a complex problem that requires detailed study and is highly specific to region and use case. For example, curtailed renewable electricity used to make hydrogen via the electrolytic pathway will increase the overall renewable deployment by using renewable energy that would otherwise be wasted. Hydrogen produced via the thermal pathway is a net gain in total electrical resources (greater than battery electric vehicle [BEV] or catenary), but it typically uses a non-renewable feedstock, unless from biogenic sources. Overall, the proper use of hydrogen is key to market impact and to maximizing net-zero goals.

**Improve performance in cold weather.** Cold-weather refueling can be a challenge

**Diesel-Electric Locomotive with a Battery Tender**

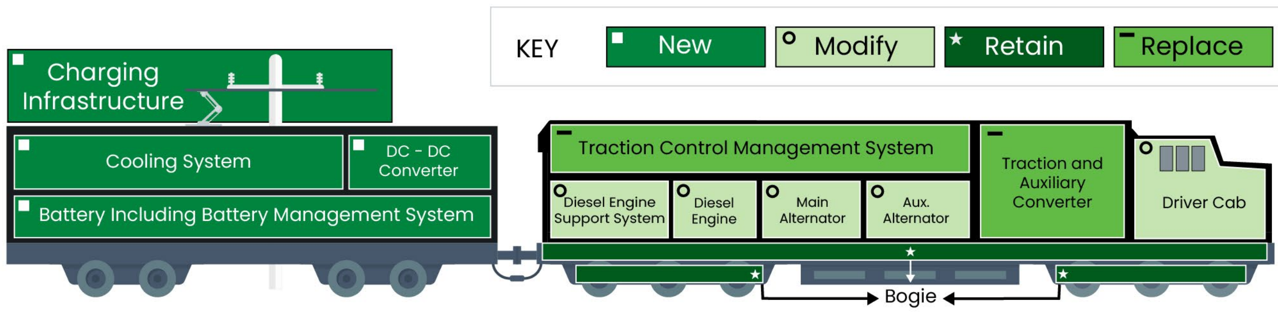



*Figure 16: Diesel-electric locomotive with a battery tender*

with $GH_2$ refueling.[107] This problem has been addressed in light-duty vehicles with different nozzle designs, but it highlights the need for refueling standards in rail.

**Increase range.** While they are better than battery-only trains, HFC locomotives have a fraction of the range of diesel or catenary locomotives. Onboard energy can be dramatically increased with the use of hydrogen tenders, which are under development but not yet commercially available.[108] Developing hydrogen tenders and safe mechanisms to transfer fuel to the locomotive is a key priority for long-term viability of HFC locomotives for long-distance rail routes.

## 5.4 Transitional Technology Pathways

As we plan and prepare for the fully decarbonized rail system of the future, it is important to consider pathways to reduce emissions in the interim. Catenary systems, hydrogen refueling infrastructure, and battery-charging stations will take time to plan and build. In the meantime, certain technologies and fuels can support immediate reductions in rail sector emissions with minimal changes to infrastructure or equipment. This section discusses four options that can reduce emissions today while also supporting a transition to full zero-emission technologies as these assets approach the end of their useful lifetimes. These technologies are expected to be used in the transition phase and are not the focus of long-term zero-emission planning. However, their use may continue up to 2050 in a limited capacity in legacy locomotives and in hard-to-decarbonize portions of the network.

### 5.4.1 RETROFITTING EXISTING DIESEL-ELECTRIC LOCOMOTIVES WITH DUAL-POWER CAPABILITY

Swappable containerized battery approaches are being considered in rail and maritime applications around the world. Because diesel-electric locomotives in the United States already contain electric traction motors, they can be retrofitted to accept a battery tender for a fraction of the cost of a new locomotive.[j, 109] Australian mining company Aurizon is piloting the world's first containerized battery tenders that work in conjunction with a conventional diesel locomotive or with a battery locomotive (Figure 16).[110] China has deployed a 700-container ship along a 1,000-mile route powered entirely by containerized batteries that can be taken on and off the ship and replaced with charged batteries.[111] Several U.S. companies have proposed concepts to retrofit existing locomotives. Such retrofits can't be completed without coupling the new energy sources to the existing power control systems, and so it will require coordination among manufacturers. UP announced in 2024 the first diesel-battery

j For example, AmePower, an industry specialist on traction converters, can retrofit existing locomotives to accept a battery or hydrogen tender for an estimated $750,000 per locomotive (not including the cost of the battery or hydrogen tender).

hybrid switcher locomotive using a "mother-slug" arrangement, in which two locomotives are linked together with independent motive power (diesel-electric in the "mother" and batteries only in the "slug") and independent tractive power.[112] NS is also considering this model.[113]

One major benefit of such a modular approach is that these containerized batteries can be dispatched to the grid in times of anticipated electricity shortages.[114] In a future where technological breakthroughs may dramatically change the economics of a specific technology for a given sector, investing in equipment that can be used across multiple sectors will help reduce the risk of stranded assets.

### 5.4.2 HYBRID AND DUAL-MODE LOCOMOTIVES AND TRAINS

The long lifetimes of locomotives combined with the lengthy deployment timelines for charging infrastructure open the door for hybrid options. One opportunity to ensure interoperability of line-haul operations while utilizing existing infrastructure is to consider hybridization and retrofits of existing locomotives. Dual-mode trains can be designed in multiple forms. A single locomotive can be equipped with both a diesel engine and battery technology, like hybrids or plug-in hybrids in light-duty vehicles. Alternatively, existing locomotives can be retrofitted to accept a battery or hydrogen tender. Another option is to use a fully battery electric locomotive in a train with other diesel-electric locomotives in a hybrid consist.

**Hybrid and plug-in hybrid battery electric diesel locomotives.** Alstom is building new hybrid battery-electric diesel-electric locomotives that are estimated to reduce diesel fuel consumption by about 11%, without requiring trackside charging for the battery. These locomotives charge the batteries with the diesel engine. Alstom emphasizes the importance of a modular number of battery packs for flexible ranges and using tactics such as regenerative braking to ensure long-lasting batteries so there is less need for new infrastructure.[115] Progress Rail is also working on a new hybrid diesel-battery electric locomotive.[116] CN recently announced the first purchase of a plug-in hybrid battery-electric-diesel locomotive for mainline freight service in North America.[117]

**Dual-mode electric and diesel trains.** New Jersey Transit Corporation (NJ TRANSIT) currently operates the only discontinuous catenary systems using dual-mode diesel-catenary locomotives in the United States. Amtrak's newest purchase includes 50 Siemens Chargers train sets that have dual-power capability to run on catenary when available and diesel otherwise, along with 15 hybrid battery electric train sets.[118] MTA Metro-North has 33 dual-mode diesel-electric/third-rail locomotives in operation or under contract.[119]

**Battery locomotives in diesel consists.** Diesel-electric locomotives can be augmented with battery electric locomotives and integrated into captive-service operations with existing locomotives to leverage regenerative braking power, as shown by the BNSF-Wabtec demonstration in 2021. Notably, these locomotives must return to a home base to charge and would disrupt interoperability if used on a train without charging access along the route or at the final destination.

**Diesel-Electric Locomotive with AC Catenary Power on the Passenger Car**


*Figure 17: Diesel-electric locomotive with AC catenary power on the passenger car*

#### 5.4.3 SUSTAINABLE LIQUID FUELS

**Sustainable liquid fuels** include fuels that are produced through renewable feedstocks such as biomass and waste oils.[11] They can have low- or net-zero carbon emissions when considered on a full life cycle basis and can be used in vehicles designed to operate on fossil fuels leveraging existing fueling infrastructure. Renewable diesel (RD) and biodiesel (BD) are examples of fuels that can be used in locomotive engines. These fuels offer an additional opportunity to decarbonize locomotives, but do not solve tailpipe emissions issues (which include both GHGs and criteria air pollutants). Their adoption will largely depend on future availability and cost as well as the degree of success of zero-emission locomotives. This plan supports deploying sustainable liquid fuels to support interim (pre-2040) decarbonization, for legacy locomotives, and in remote and hard-to-decarbonize operations, such as those with significant limitations on recharging/refueling infrastructure capacity. Their role is anticipated to decrease over time as adoption of zero-emission locomotives expands. The use of biofuels in locomotives will depend on biofuel production volumes and cost as well as adoption rates of zero-emission technologies. More information on the role of biofuels in decarbonization can be found in **Appendix A.**

Biofuel options for rail may include BD, RD, bio-oils, ethanol, methanol, dimethyl ether, and others. RD requires minor changes to the engine compared to petroleum diesel, and the two main providers of engines will have 100% RD approved for use by the end of 2024. Effective policy can incentivize industry to further reduce GHG emissions (70% to over 100% reductions have been demonstrated). Criteria tailpipe emissions from ICEs can be reduced but are unavoidable, yet RD can be produced selectively with virtually no aromatics, enabling significant reductions in particulate-matter emissions compared to petroleum diesel fuel. Policy to incentivize aftermarket emissions reduction technologies is also a need.

#### 5.4.4 HYDROGEN INTERNAL COMBUSTION ENGINES

Hydrogen internal combustion engine ($H_2ICE$) pathways involve retrofitting existing diesel locomotive engines to be able to accept a mix of hydrogen and diesel. Three $H_2ICE$ pathways are under R&D that would allow a locomotive to burn a mix of 50% hydrogen and 50% diesel up to potentially 90% hydrogen and 10% diesel. While $H_2ICE$ will inevitably produce $NO_x$ emissions, preliminary results from studies underway that are making direct comparisons of $H_2ICE$ and diesel $NO_x$ emissions seem to indicate potentially lower $NO_x$ emissions from the $H_2ICE$ under specific conditions. Compared to after-treatment packages for selective catalytic reduction (SCR)-controlled diesel engines, a smaller volume of catalyst may be sufficient for $H_2ICE$ in some cases. For diesel engines that utilize exhaust-gas recirculation in lieu of SCR for $NO_x$ control, investigations would be needed regarding possible simplifications of exhaust gas recirculation systems on engines using hydrogen as fuel. $H_2ICE$ technology has several favorable attributes, including the use of the existing engine platforms and insensitivity to hydrogen quality, which can enable rapid and widespread deployment of both powertrains and associated infrastructure that could later support fuel-cell rail applications. Such fuel flexibility can significantly reduce customer anxiety over hydrogen availability. Moreover, $H_2ICE$ can operate in hot and high-vibration environments that are typical of rail applications. Wabtec is currently working with Oak Ridge National Laboratory and Argonne National Laboratory on the development of $H_2ICE$ injection technologies.

It is not yet clear how significant $NO_x$ impacts from hydrogen combustion will be in the transportation space. To date, most published studies of hydrogen combustion have focused on its use in stationary-source power plants, most notably plants that currently use natural gas as their primary fuel, and from work in industrial applications. However, many of these studies have indicated significant issues

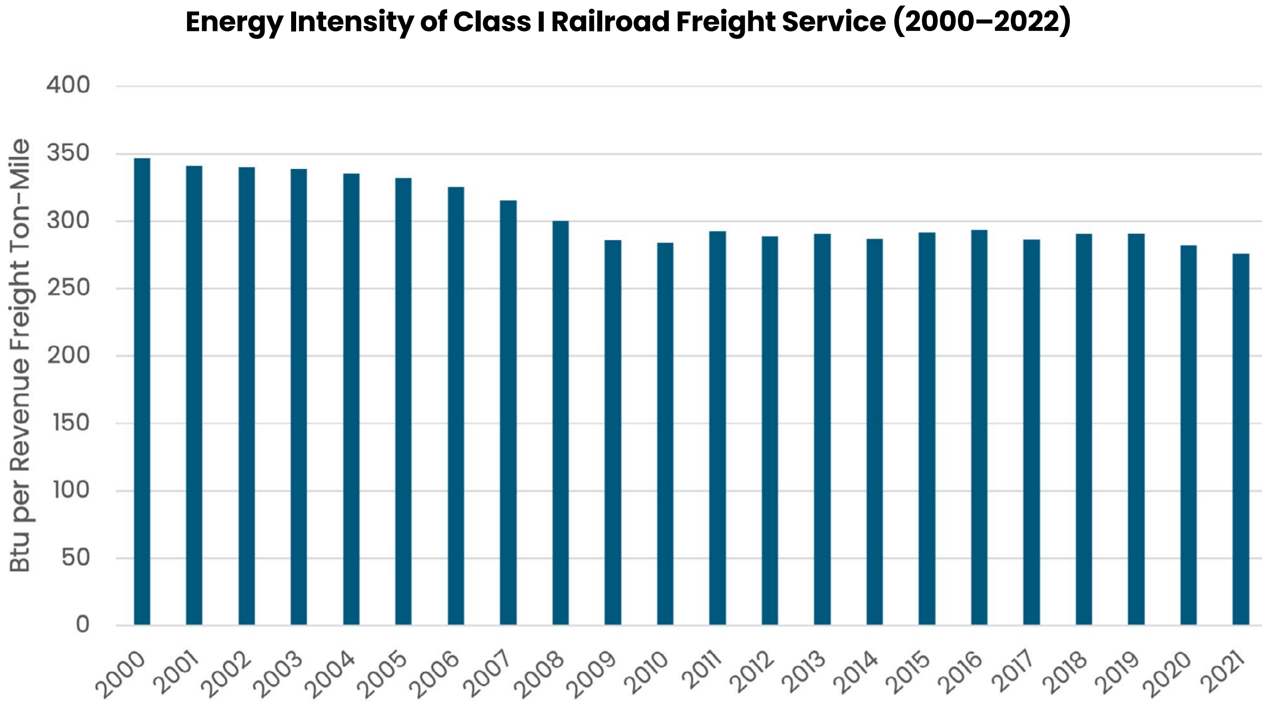



*Figure 18: Energy intensity of Class I railroad freight service (2000–2022)*

with controlling $NO_x$ emissions from hydrogen combustion.[120, 121, 122] Discussions with rail-industry stakeholders have suggested that the conditions that best lend themselves to lower $NO_x$ emissions compared to diesel are those with neat hydrogen, using no diesel pilot fuel. However, to date, we are not aware that any rail-industry stakeholders have determined that such a configuration is feasible for locomotive operations. Tests of high-hydrogen blends with diesel are ongoing, but more work must be completed before conclusions can be drawn about the potential to minimize $NO_x$ emissions. $N_2O$ and particulate matter (PM) outcomes from different levels of hydrogen blending are also still uncertain. However, $H_2$ICE will still face the same hydrogen production, distribution, and storage challenges as HFC technology.

DOE's Hydrogen Program Plan identified potential issues with $H_2$ICE safety and durability.[123] R&D is needed to address issues such as auto-ignition, flashback, thermo-acoustics, mixing requirements, aerothermal heat transfer, materials issues, turndown/combustion dynamics, $NO_x$ emissions, and other combustion-related phenomena. In addition, when hydrogen concentration exceeds 75%, there is a significant change in combustion behavior, requiring new combustor designs, different sensor locations, and new control schemes.

## 5.5 Efficiency

In addition to decarbonization measures to reduce the CI of rail motive power, overall energy needs for transportation can be reduced by making locomotives more energy-efficient and by shifting cargo and passengers from less energy-efficient modes to rail. Rail transport is more energy-efficient than road transport because there is less friction between steel wheels on steel rails than between rubber tires and asphalt. This section describes potential emissions reductions from different levers to increase both rail and transport system efficiency. Importantly, these opportunities must not come at the expense of safety.

**Types of Modifications to Railcars to Reduce Aerodynamic Drag**

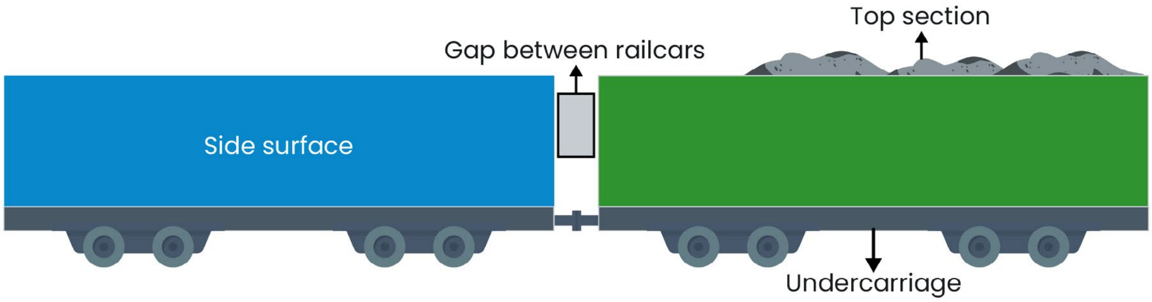



*Figure 19: Types of modifications to railcars to reduce aerodynamic drag*

"Energy efficiency" refers to the use of less energy to perform the same task or produce the same result. This includes reducing losses that are inherent in any conversion or consumption of energy, including opportunities for the industry to develop and deploy technologies that improve the overall energy efficiency of the locomotive. Figure 18 shows that after a steady decrease in the first decade of the 21st century, freight rail energy efficiency has remained relatively flat (around 300 British thermal unit [Btu]/ton-mile) since 2009.[74]

### 5.5.1 TRAIN EFFICIENCY

**Train efficiency.** "Train efficiency" can be defined as the actions that can be taken wayside on the track or off board the locomotive with the railcars. The top three types of resistances in a train are rolling, bearing, and air. Due to the nature of the resistances, they vary with speed and type of goods hauled. Actions to increase train aerodynamics by modifying railcars can provide energy savings regardless of current or future powertrains. For example, a 30% reduction in train drag results in 2.8% fuel savings. For the Class I rail operators, each 1% of fuel saved results in $220 million saved, assuming a $3.50/gallon diesel price. Importantly, these fuel savings will translate into energy savings whether the locomotive is powered by hydrogen, biofuels, or electricity. Intermodal freight resistance varies by speed.[124] As speeds increase, air resistance makes up a greater and greater proportion of total resistance. Air resistance makes up more than 50% of resistance to the train at speeds over 35 mph.[k] This exponential increase is due to air resistance being proportional to the square of speed. There are four key areas to help address aerodynamics of a train (Figure 19): side surfaces, undercarriage, top section, and gap between railcars. Computer-fluid dynamics analysis shows fuel improvements can exceed 10% based on the modifications done to the railcars and gaps.[125] Actions to increase train aerodynamics can provide energy savings regardless of current or future powertrains. A NASA study found that by adding covers, coal cars reduced aerodynamic drag 29%–41% for yaw angles between 0° and 10°,[126] potentially improving fuel efficiency by 9%.

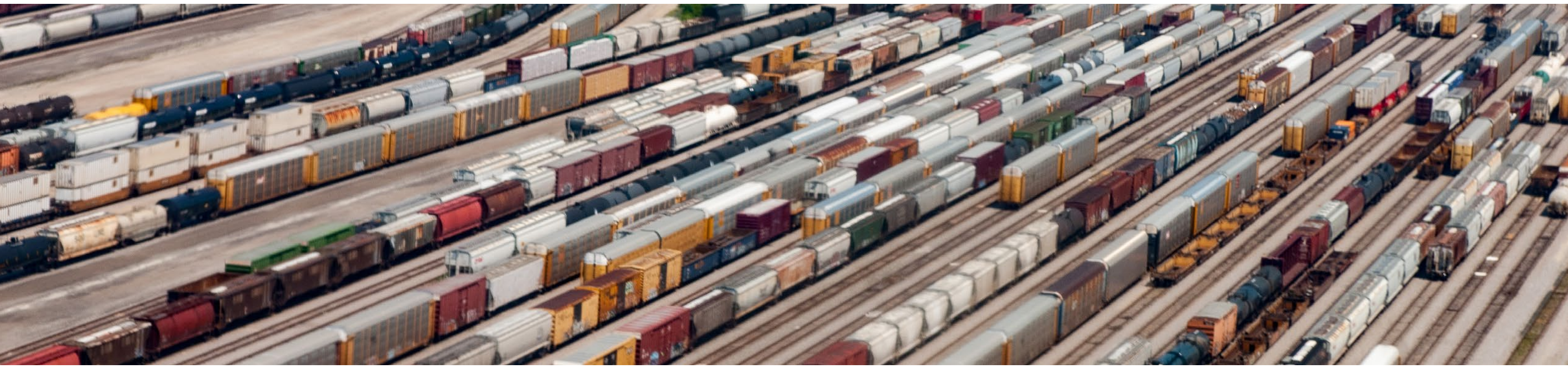
k The nature of steel wheels on steel rail, the rolling resistance is already very low as compared with trucking and is not a priority for investment. Similarly, previous research has found that upgrades in wheel bearings provide a marginal-at-best improvement to efficiency. A 2009 FRA report concluded that targeting bearing resistance is an inefficient way to improve train efficiencies: railroads.dot.gov/sites/fra.dot.gov/files/fra_net/2925/Comparative_Evaluation_Rail_Truck_Fuel_Efficiency.pdf.

**Locomotive efficiency.** The "locomotive" can be defined as the power unit of an overall train. A freight train could have multiple locomotives powered and lots of unpowered railcars. A passenger train could either have a powered locomotive and unpowered passenger cars or be a multiple unit, where each passenger car has powered axles.

- **Rolling resistance.** The main option to reduce rolling resistance for a locomotive is a sander, which applies sand to the leading axles of each truck, which improves the friction between the wheel/rail interface. They are the most cost-effective and easiest to operate and maintain.
- **Air leaks.** The locomotive(s) provide compressed air to the entire train to actuate the brake systems on the locomotive as well as railcars. When there are air leaks throughout the railcars and locomotive, the air compressor must run more, which consumes more energy. Southwest Research Institute found that fixing air leaks can reduce train energy use by up to 14%.[127]
- **Digital products for energy management.** Multiple products installed on locomotives can be used to optimize fuel usage. Examples of products are Wabtec's Trip Optimizer and Progress Rail's Talos.

**Engine efficiency**. The ICE is the prime power source of the train. There are three main ways to increase engine efficiency for legacy locomotives, reducing fuel use and, therefore, emissions.

- **Generator/Alternator Turbochargers (eTurbo).** An alternator/generator is introduced to the turbocharger on the prime mover (engine). The modified turbocharger allows for more of the waste energy produced by the exhaust of the engine to be converted into useable energy for the locomotive.
- **Fuel Injection Pressure.** Higher-injection pressures coupled with advanced combustion recipes lead to a more complete burn of fuel, which improves fuel consumption and reduces smoke emissions**, particularly in medium- and low-speed engines.**[128]
- **Hybrid Powertrains.** Like the automotive industry, rail prime movers stand to make large gains in efficiency by incorporating batteries to create a hybrid powertrain:
  - With a larger battery pack, the electric air compressor and other auxiliary electrical loads can be powered from the stored energy, allowing the engine to stay off.
  - Batteries absorb some of the transient load demands from the locomotive, allowing the engine to stay in its optimal power zone for longer.
  - A battery hybrid can capture the energy normally lost from dynamic braking.
  - Depending on the size of the battery pack, the locomotive may be able to shut down its prime mover for short periods of time, drastically reducing local emissions.



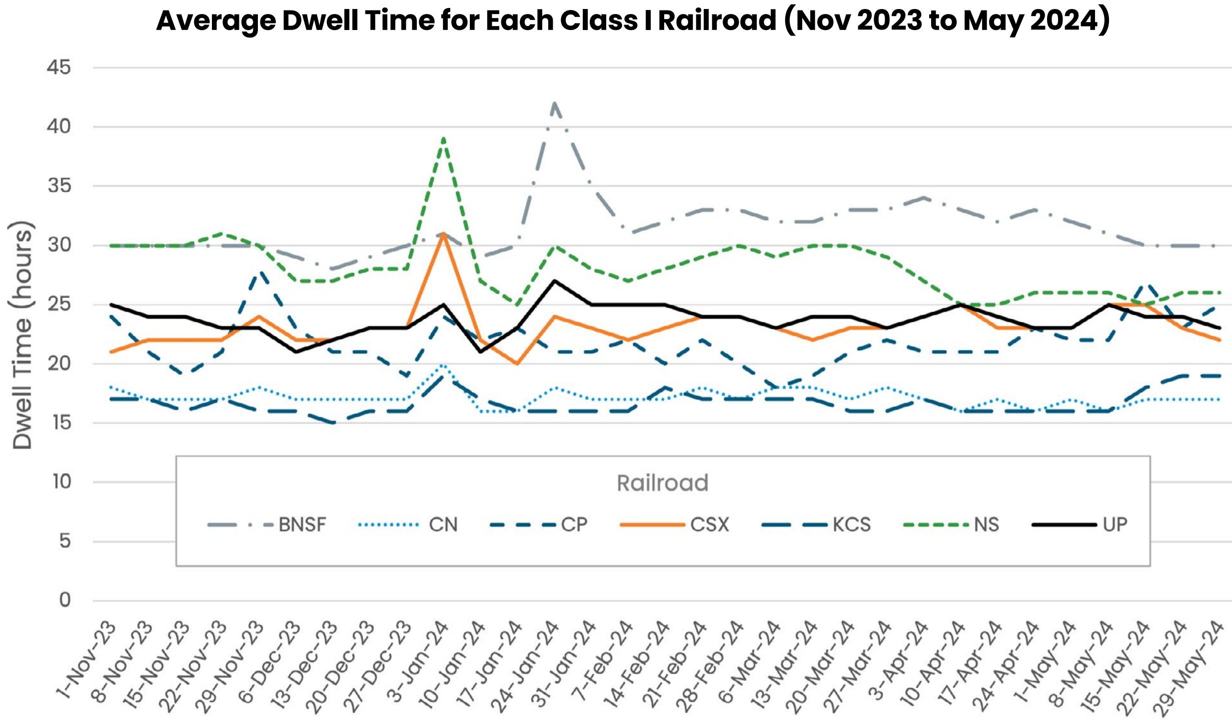



*Figure 20: Average dwell time for each Class I railroad (Nov. 2023 to May 2024; source: RSI logistics)*

### 5.5.2 RAIL OPERATIONS EFFICIENCY

Freight rail system congestion leads to additional fuel use and downstream impacts on delayed passenger rail, all of which push shippers and passengers to other timelier (but less energy-efficient) modes, such as single-occupancy vehicles (SOVs) or trucks. The freight rail network has seen increasing congestion over the past few years, with some rail yards holding boxcars for upward of 40–50 hours before transferring to their next train.

### 5.5.3 TRANSPORTATION SYSTEM EFFICIENCY

While efforts to decarbonize the rail industry are necessary to reach net-zero GHG emissions goals, the rail system can help other modes reduce GHG emissions as well, through mode shift initiatives and policies. "Mode shift" refers to changing the mode for transporting people or freight between an origin and destination. Because of rail's increased efficiency over other modes, even with current diesel locomotive technology, shifting a passenger from a SOV to passenger rail decreases the GHG emissions associated with moving that person from Point A to Point B (commonly expressed in units of GHG emissions per passenger mile). The same is true for freight—shifting freight from a truck to rail decreases the GHG emissions associated with moving that load of freight from Point A to Point B (commonly expressed in units of GHG emissions per ton-mile). Aside from GHG emissions, cars and trucks have documented negative impacts on many dimensions of society, including noise, air pollution, hospital visits, deaths, and social isolation, among others.[129] Increasing use of rail modes for passenger and freight travel will use existing infrastructure in a more energy-efficient way while also reducing the other harms of automobiles and trucks.

To reduce the overall energy per ton-mile or passenger-mile in the transportation system, infrastructure investments should be targeted to encourage rail use for freight and passenger applications. Mode shift presents an opportunity for the freight rail sector to capitalize on a greater

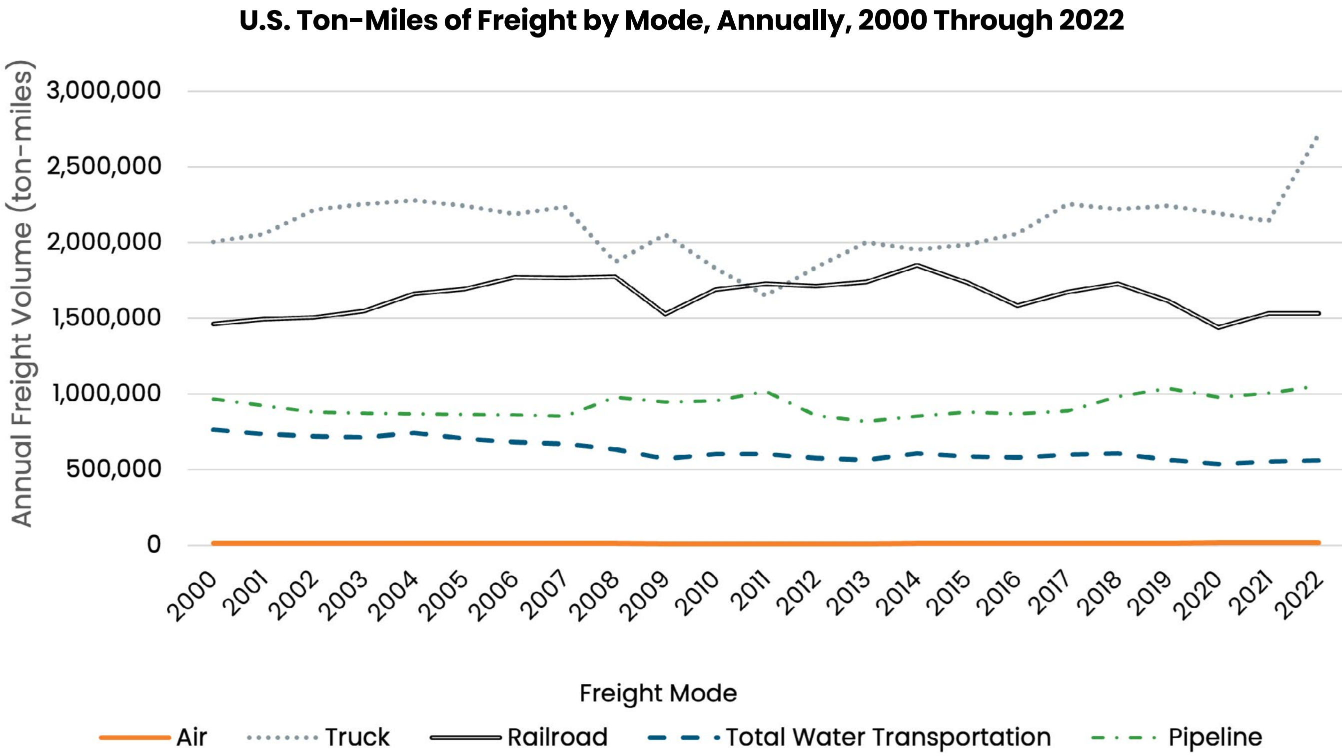



*Figure 21: U.S. ton-miles of freight by mode, annually, 2000 through 2022*

share of the transportation market. Figure 21 shows that beginning around 2014, freight truck market share (blue) began accelerating as the freight rail market share (orange) began falling. As other transportation modes decarbonize their operations, they will become more competitive and accepted by the public and they could outcompete the rail sector if it does not keep pace and modernize operations.

### *5.5.3.1. PASSENGER MODE SHIFT*

In 1920, the U.S. rail network boasted approximately 250,000 route miles and 98% of all commercial intercity travelers in the United States moved by rail.[130] Today, it is about 140,000 route miles, a 44% decrease over the past century. Still, Americans' interest in passenger rail is growing. For example, Amtrak carried 28.5 million passengers in FY 2023, a 25% increase from the previous fiscal year,[131] and is on target to set a new ridership record by exceeding the 32.3 million passengers who rode Amtrak pre-pandemic.[132]

Increasing access to intercity passenger rail will provide more Americans the option of pursuing this efficient mode of transportation. Because intercity rail-passenger service runs on the freight railroad network in much of the country, increasing passenger service in the United States requires overcoming barriers, including upgrading tracks to increase potential passenger-train speeds. Robust and reliable funding is important to improving and expanding intercity passenger rail.

A recent EPA study highlights the benefits of passenger rail by comparing $CO_2$ emissions savings if people chose to take the train over flying between city pairs in the northeastern United States.[133] For routes less than 500 miles, substantial savings of about 100 pounds (lb.) $CO_2$ per passenger could be saved by taking the train instead of flying, even if that train is powered by a traditional diesel engine. If the train is electric, $CO_2$ savings per passenger are even greater—up to 200 lb. $CO_2$ per passenger for routes less than 500 miles—and savings continue to increase, although they level off with increasing route distance. However, currently Amtrak's NEC stretching from Boston, MA, to Washington, D.C. represents the longest electrified passenger rail route in the United States, at 457 miles. On the electrified NEC, Amtrak travel emits up to 83% less GHG emissions compared to car travel and up to 72% less GHG emissions than flying. On average, Amtrak service is 46% more energy efficient than travel by car and 34% more efficient than domestic air travel.[134]

Using EPA's MOVES4 model and assuming national scale default inputs for light-duty vehicle-fleet fuel efficiency in the year 2024, up to a 69% reduction in $CO_2$ operational emissions occurs by switching from SOV to (diesel-powered) rail. That savings increases to 85% when switching from SOV to electric rail (e.g., NEC) and including GHG emissions from the generation of electricity for motive power. Savings would be 100% if only considering operational emissions. An analysis performed by U.S. Department of Transportation (DOT) Volpe Center for FRA had similar results when analyzing four real-world routes between city pairs in the United States, but also included buses and Amtrak's Auto Train route, where passengers could bring their personal vehicles onto the train as freight.[135] Expanding affordable rail access is one of the key strategies to provide energy-efficient long-distance travel options.

Public transit investment is an important strategy to reduce transportation-sector emissions, saving an estimated 63 MMT $CO_2e$ emissions annually in the United States, or almost twice as many emissions as the entire rail sector.[136] Boosting public transit ridership can directly reduce GHG emissions by displacing trips in SOVs. Transit investments also indirectly reduce GHG emissions by enabling compact, mixed-use development and 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. Decarbonization that reduces vehicle miles traveled (VMT) through smart land use and growth, such as transit-oriented development (TOD), integrated land use and transportation planning, along with designing walkable communities, are discussed in greater detail in the *Convenient Transportation: An Action Plan for Energy and Emissions Innovation.*

#### *5.5.3.2. FREIGHT MODE SHIFT*

Much research has documented the potential carbon-emissions reduction benefits and additional benefits of a shift from less efficient modes to rail. A 2015 Congressional Budget Office (CBO) report identified the median external cost of trucks as eight times higher than that of freight rail.[137] Freight Analysis Framework (FAF) projects that in 2025, 800 billion ton-miles of long-haul freight will be carried by trucks. That amounts to a $40 billion external cost to society using the CBO external costs. A hypothetical mode shift of that freight would result in a reduction of those costs to $5.6 billion, a $34.4 billion savings to our nation. Oliver Wyman estimated that a business-as-usual 20% decrease in rail mode share to trucking would come at a high social cost, including an estimated 16,000 deaths and 660,000 serious injuries from car crashes, an additional $332 billion in road expansion and maintenance, and 230 terawatt hours of power annually.[138]

While shipping by truck may offer greater flexibility on shipping times and destinations, rail offers substantial GHG emissions savings over trucks, even with existing diesel locomotive technology. A 2022 Texas A&M Transportation Institute report highlights rail as about three times as fuel efficient as trucks (472 ton-miles per gallon versus 151 ton-miles per gallon for trucks).[139] Argonne National Laboratory's 2017 study estimated that shifting 4.1% of truck ton-miles to rail would reduce total freight system energy use by 4.3% by 2040.[140] For 1 million ton-miles, shipping freight by truck would result in 140.7 metric tons of GHGs, while that same shipment by rail would only emit 21.6 metric tons of GHGs—nearly an 85% savings.

A 2008 study suggested that 25% of freight could be shifted from trucks to rail at a lower cost if the infrastructure existed, leading to

**Table 9: Freight-Flow Segments and Corresponding Rail Requirements, Potential, and Development Status**

| Market segment | Bulk mineral exports or imports | Mineral distribution industries | Movement of intermediate manufactured commodities | Movement of manufactured and fast-moving consumer goods between distribution centers | Rural freight |
|---|---|---|---|---|---|
| Typical commodities | Coal, iron ore, manganese | Coal, iron ore, manganese | Steel coils, bulk cement | Palletized commodities that can easily be containerized | Mixed |
| Network | Dense purpose-built lines | Purpose-built lines (often through rural areas) | Connecting industries through sidings | Dense corridors | Low-density flows |
| Terminals | A few densified and purpose-built loading points | Connection between purpose-built loading points and sidings | Siding-to-siding traffic | Intermodal facilities linked with sidings | Rural distribution and collection centers |
| Rail solution | Heavy-haul or unit trains between industries and ports | Unit trains between mines and industries | Groups of coupled wagons between sidings | Heavy intermodal unit trains between logistics hubs | Carloads with facilities for connecting and disconnecting cars |
| Road interface | No road redistribution | Limited road redistribution | Some road redistribution | Seamless interface between road and rail, will always require last-mile distribution | Typically, more road-friendly |
| Modal shift potential to rail | Up to 100% | 60%–80% of all freight | 40%–60% of all freight | 40%–60% of all long-distance unitized fast-moving consumer goods movements close to densified corridors | Low |

an 80% reduction in social costs of emissions, congestion, and safety.[141] A 2007 study found that freight modal shift from truck to rail could significantly reduce roadway congestion.[142]

**Table 9** replicates a table from the International Energy Agency on the target markets for a mode shift from trucks to rail.[143] This framework underscores where supportive infrastructure can be planned and constructed. Detailed analysis on rail infrastructure and service quality improvements is required to achieve the potential identified modal shifts from trucks to rail.

Roll-on/roll-off and similar technologies have been around for decades and continue to be used in places such as Switzerland. They offer methods of mode shift that do not need to cause additional negative impacts on overburdened trackside communities. Restoring short-line railroad service in rural places can also stabilize communities and rebuild economic opportunities. A University of Minnesota Extension study analyzed the impacts of restoring a short-line railroad in Minnesota.[144] These investments in connecting communities to rail offer a pathway to reverse population decline and increase the local tax base by retaining and attracting industries that are too small to be attractive to a Class I railroad and lack rail service to reach them. Returning carload service to communities with investments in short-line railroads is another underutilized tool for mode shift that reconnects America and builds a more resilient supply chain.

**Roll-On/Roll-Off System in Switzerland**

*Figure 22: Roll-on/roll-off system in Switzerland. Image courtesy of Reservations Solutions Company (RAlpin)*

## 5.6 Convenient Access to Passenger Rail

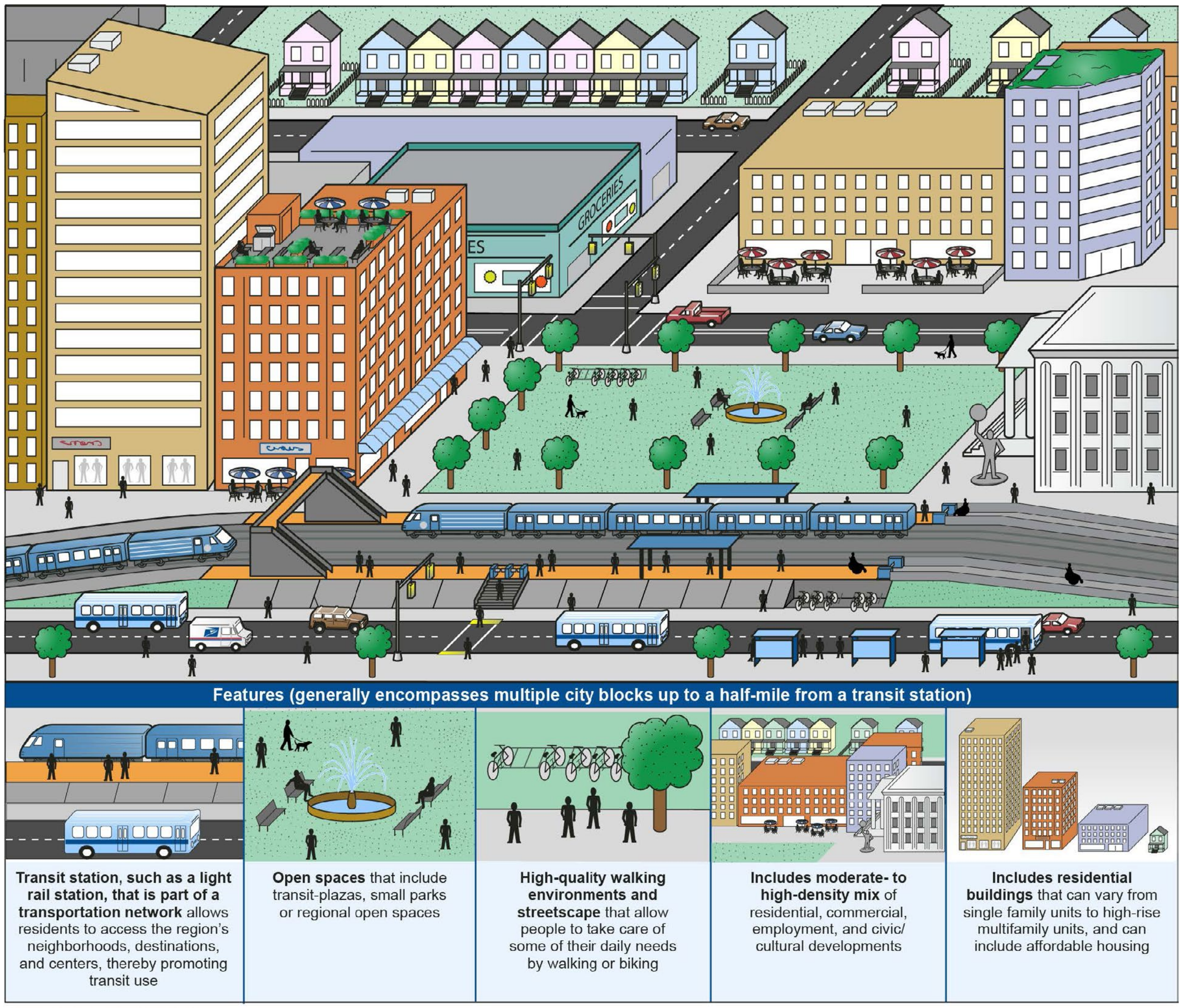
For intercity passenger rail (especially HSR), allowing for dense commercial activity centers adjacent to and surrounding major intercity rail stations is of particular importance to make access to and use of rail systems more convenient for all travelers. Integration of these major hubs into the local mass transportation network also helps facilitate last-mile connections when traveling by train. FRA developed the reference document *Station Planning for High-Speed and Intercity Passenger Rail*, which established three key planning principles for new and revitalized stations:

- **Location:** Optimize the station location.
- **Transportation:** Maximize station connections with other transportation modes.
- **Development:** Shape the station area through urban design and focus infill development around the station.

The above principles align closely with TOD concepts. TOD connects neighborhoods and communities with equitable and accessible public transit and multimodal transportation options. When jobs, retail and commercial development, and housing are clustered around high-quality transit and rail nodes, people can choose to drive less often—resulting in cost savings, less congestion, and fewer emissions. For example, the Maryland Department of Transportation estimates that people who live, shop, or work in proximity to TOD in Maryland drive 20%-40% less and reduce GHG emissions by 2.5 to 3.7 tons annually per household.[145]

TOD also uses less land than conventional, low-density development, which can help preserve farmland and other lands with high ecological value. “Infill” development is a common feature in TOD and urban planning, in which unused or underutilized parcels of land are developed and densified. Urban infill often involves building in and up rather than sprawling out. It is a key component of the 15-minute-city strategy, which allows residents in a neighborhood to meet most of their daily needs within a short walk, bike ride, or transit trip of their home.[146]

**Common Features of Transit-Oriented Development (TOD)**



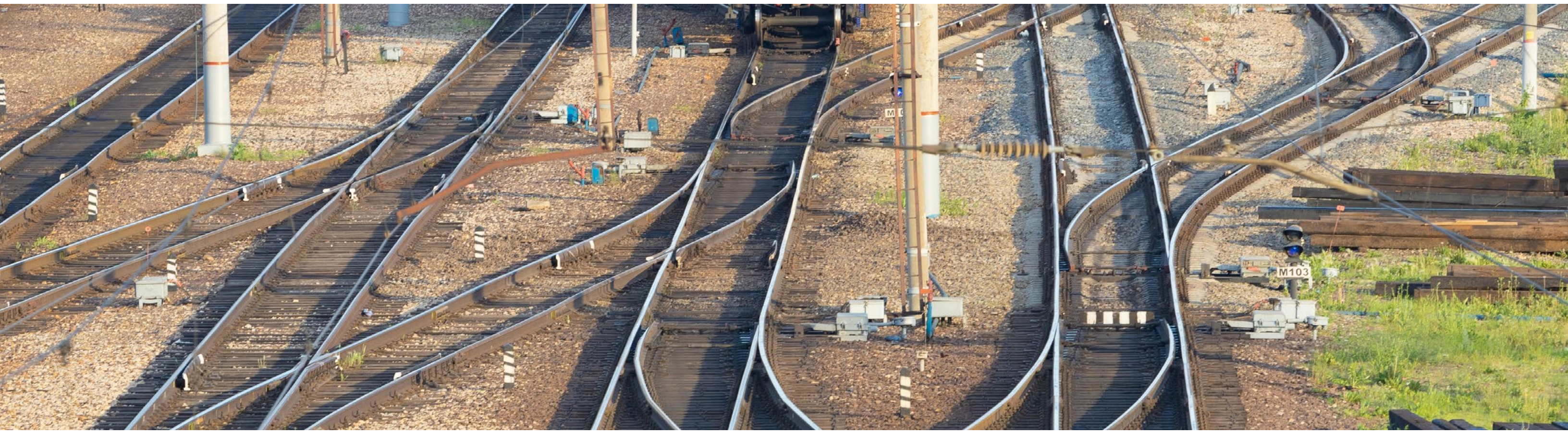

Source: GAO. | GAO-22-104536

*Figure 23: Common features of transit-oriented development (TOD)*[147]

Typically, TOD focuses on compact, mixed-use development near an intracity transit station. Although the frequency and purpose of trips taken on intercity rail may differ from an intracity transit system, intercity stations can also be a focal point for TOD.[148] Key TOD strategies for rail station planning include:[149]

**Location and Connectivity**

- Place station near existing urban cores, downtown areas, or major highway/street access points.
- Reroute and add public transit service and ensure connections to major activity centers.
- Coordinate arrival and departure schedules among intercity rail, transit, and bus services.
- Investigate opportunities for modal integration for ticketing.
- Provide pedestrian and bicycle connectivity between the station and the surrounding neighborhoods.
- Prevent automobile access to the station from impeding bike, pedestrian, and transit access.



**Mixed-Use Development**

- Create public development corporations with diverse governmental and nongovernmental stakeholders to ensure development occurs with an eye toward the long term.
- Promote compact mixed-use infill developments with affordable housing and value-priced parking.
- Assure surrounding zoning permits multiple uses at all times of the day.
- Encourage a mix of retail, residential, and other uses to encourage a sense of community and prevent zones from becoming "nine-to-five" employment centers.
- Consider implementing minimum density requirements to prevent sprawl.
- Consider value capture opportunities such as business improvement districts that could provide revenue to the rail agency.

**Land Use and Zoning Policies**

TOD involves long-term planning and implementation at the local level. Historically, zoning codes required strict separation of uses (e.g., residential vs. commercial districts) and limited the density of urban cores and downtown areas. Updating zoning and other land-use codes, regulations, and policies can promote denser, mixed-use development with more accessible transit and rail service. For example, Denver's Union Station project team worked to rezone the surrounding area for TOD so that the historic station and nearly 20 acres of surrounding land could be redeveloped and preserved.[150] Union Station integrates Amtrak rail service, light-rail and commuter-rail lines, regional buses, taxis, shuttles, and bicycle and pedestrian access. The station area has also become a thriving transit hub and cultural center with many dining and activity options for travelers and the adjacent neighborhoods.

Dense urban areas need high-quality transit service to allow people to move conveniently and efficiently. Similarly, increasing residential density can support high-quality transit, providing levels of ridership that can sustain frequent and affordable service. There is a strong positive correlation between station-area land-use density and absolute ridership volumes. Putting more origins and destinations close to a rail station of any kind (and ensuring that the public realm is direct, safe, and comfortable for walking trips to and from the station) increases the decarbonization potential of any rail investment, as it yields more modal shift from modes such as driving. This can be done via adjustments to local land-use regulations, or state-level land-use policies, such as the Multi-Family Zoning Requirement for MBTA Communities in Massachusetts.

# 6. KEY ACTIONS: GETTING TO 2030

To set the U.S. rail sector on a decarbonization trajectory at a pace commensurate with the urgency of climate change,[151] this plan defines a short-term suite of actions to:

- Transition line-haul rail toward significant catenary electrification over the long run, while supporting research, development, and deployment of HFC and battery locomotives and scaling up sustainable liquid fuel production.
- Address public health concerns from rail yard activities in environmental justice communities to the greatest extent possible by 2030.
- Increase access to freight and intercity-passenger-rail service.

Key actions to carry out the strategy for rail decarbonization involve leveraging historic amounts of federal funding from BIL and the Inflation Reduction Act (IRA) to initiate planning for long-term rail electrification, deploying measures to reduce air pollution from locomotives, improving rail-system efficiency, and expanding access to convenient and affordable transit and passenger rail. This infrastructure planning should leverage the National Zero-Emission Freight Corridor Strategy, which outlines a multi-phased electrification infrastructure plan to identify where rail would also benefit.[152] Simultaneously, a near-term research, data collection, and outreach agenda lays the groundwork for long-term electrification infrastructure planning and assessing the role of hydrogen fuel-cell and battery locomotives in the rail sector. Analysis will also be needed to inform locomotive-grid integration potential across different market segments, multi-modal freight optimization, and expanding mode-shifting potential.

Collectively, these actions comprise a strategy to propel the rail sector toward significant freight and passenger line-haul electrification by 2050, reduce air pollution from rail yards as soon as possible, and develop a strategy to provide better options for both freight and passengers that encourage more efficient movement that is also affordable and convenient. For the long-term success of catenary and discontinuous catenary systems, detailed feasibility, and planning assessments on high-priority corridors for electrification are targeted to be completed by 2027. Similarly, workforce development and domestic manufacturing capabilities should be bolstered by 2030 in anticipation of long-term electrification infrastructure construction and maintenance.

## 6.1 Initiate Detailed Electrification Feasibility Studies to Support a National Zero-Emission Freight Rail Network Strategy

The most cost-effective portions of the rail network for catenary electrification are areas with high traffic volumes; inexpensive and plentiful electricity; steep grades (to recharge batteries on the way down); and strategically placed "charging islands" to shorten "gap" sections to manageable lengths for batteries or fuel cells. In a discontinuous catenary system, the highest-cost portions of the network could be avoided (e.g., tunnels, bridges, and dense urban areas) and trains could run on batteries or fuel cells. Figure 24 displays freight flows on the rail network for the contiguous United States in 2022. While the densest corridor remains the coal traffic from Wyoming to Kansas City, Missouri (depicted in blue), coal traffic continues to decline annually as the economy decarbonizes, and this route will soon no longer be as heavily trafficked.

**Freight Flows by Rail Corridor in the United States in 2022**


*Figure 24: Freight flows by rail corridor in the United States in 2022*[153]

**Highest-volume routes.** Based on current freight flows and network topography, the following corridors have attributes that make them high-potential freight corridors for full or discontinuous catenary electrification:

- BNSF's Southern Transcon connects Los Angeles, California, to Chicago, Illinois[l]
- BNSF's Northern Transcon connects Seattle, Washington, and Portland, Oregon, to Chicago, Illinois
- The Alameda Corridor connects the Ports of Los Angeles, California, and Long Beach, California, to the national rail network
- The corridor connecting Chicago, Illinois, to Pittsburgh, Pennsylvania, to Port of Houston, Texas.

**Connecting corridors for a national network of interoperability.** The following corridors represent medium-high-tonnage routes that would connect the highest-volume routes identified above. Connecting electrified routes can help maximize interoperability of electric equipment:

- The corridor of UP's Sunset Route from Los Angeles, California, to Dallas, Texas
- BNSF's corridor that connects Dallas, Texas, to Kansas City, Missouri (connects Southern Transcon to the Sunset Route)
- The corridor from Ogden, Utah, to Chicago, Illinois
- Chicago, Illinois, to Buffalo, New York
- Ogden, Utah, to Kansas City, Missouri
- Cincinnati, Ohio, to Atlanta, Georgia
- Cleveland, Ohio, to Baltimore, Maryland.

l Excepting coal traffic from Wyoming, the Southern Transcon is the highest-density rail corridor in the United States. It traverses high mountain grades through New Mexico and Arizona. Electrifying this single route, representing about 3% of the rail network, would reduce BNSF's fuel use by up to 20%.

**Intercity passenger corridors that support widespread catenary for freight rail.** Amtrak's newest locomotive purchase includes 50 Siemens Chargers that have dual-power capability to run on catenary when available and diesel otherwise.[154] These high-potential corridors for passenger electrification include sections that can leverage existing catenary infrastructure by extending the range of existing electric locomotives, as well as corridors of national significance for an HSR intercity passenger network. These routes represent high-potential corridors because they have two or more of the following attributes: direct connection to existing catenary infrastructure, frequent daily trains, and public ownership of tracks and ROW. Furthermore, many of the Chicago-based corridors overlap with high-volume freight corridors where catenary infrastructure benefits could be multiplied by serving both markets at once. For example:

- **North Carolina Railroad Corridor** runs from Charlotte, North Carolina, to Morehead City, North Carolina.
- **The "S-Line" segment** of the Southeast Corridor runs from Washington, D.C. to Raleigh, North Carolina. The S-Line is being restored for higher-speed service (110 mph) and connects to the NEC.
- **The New Haven-Springfield Line on the Northern New England Corridor** connects to the NEC.
- **The Wolverine Corridor** of the Chicago Hub Network runs from Chicago, Illinois, to Detroit, Michigan, and connects to existing catenary electrification on the South Shore Line.
- **The Empire Corridor** runs along Buffalo, Rochester, Syracuse, Utica, Schenectady, and Albany in New York and connects to the electrified third rail.
- The **Harrisburg-to-Pittsburgh, Pennsylvania**, section of the Keystone Corridor would extend electrification from the Amtrak-owned portion of the Keystone Corridor.

**Commuter rail corridors with high potential for electrification.** While these systems may not achieve the greatest GHG emissions reduction in the overall rail sector, they present critical opportunities to begin implementing catenary and discontinuous catenary systems in the U.S. context while also improving passenger-rail service quality in terms of speed, comfort, train frequency, noise reduction, and air quality. The following commuter-rail corridors have been identified as high-potential candidates for electrification for two or more of the following reasons: the tracks are publicly owned, the transit agency has already expressed interest or intent to electrify, the rail system connects to existing catenary or third-rail infrastructure, or the rail system is part of one of the congressionally designated high-speed rail corridors of national significance.

- The **MBTA** has announced plans to complete a discontinuous catenary system on the Fairmount Line by 2027.
- **NJ TRANSIT** currently operates the only discontinuous catenary systems using dual-mode diesel-catenary locomotives in the United States.
- The **Virginia Railway Express** that operates from Broad Run, Virginia, and Spotsylvania, Virginia, to Washington, D.C. would be served by electrification of Virginia Rail Passenger Authority.
- The **Chicago Metra system** has an "Electric District" already, and other high-volume Metra-owned lines are prime candidates for electrification.
- **The Utah Transit Authority FrontRunner** connects Ogden, Utah, to Provo, Utah.
- The **Long Island Rail Road** in New York is the busiest commuter rail in North America. It currently runs a mix of diesel trains and electric trains on third rail.
- **The San Bernardino Line** operated by Metrolink connects Los Angeles, California, to San Bernadino, California. This corridor would connect the electrified

**Map of High-Potential Routes for Catenary Feasibility Studies**

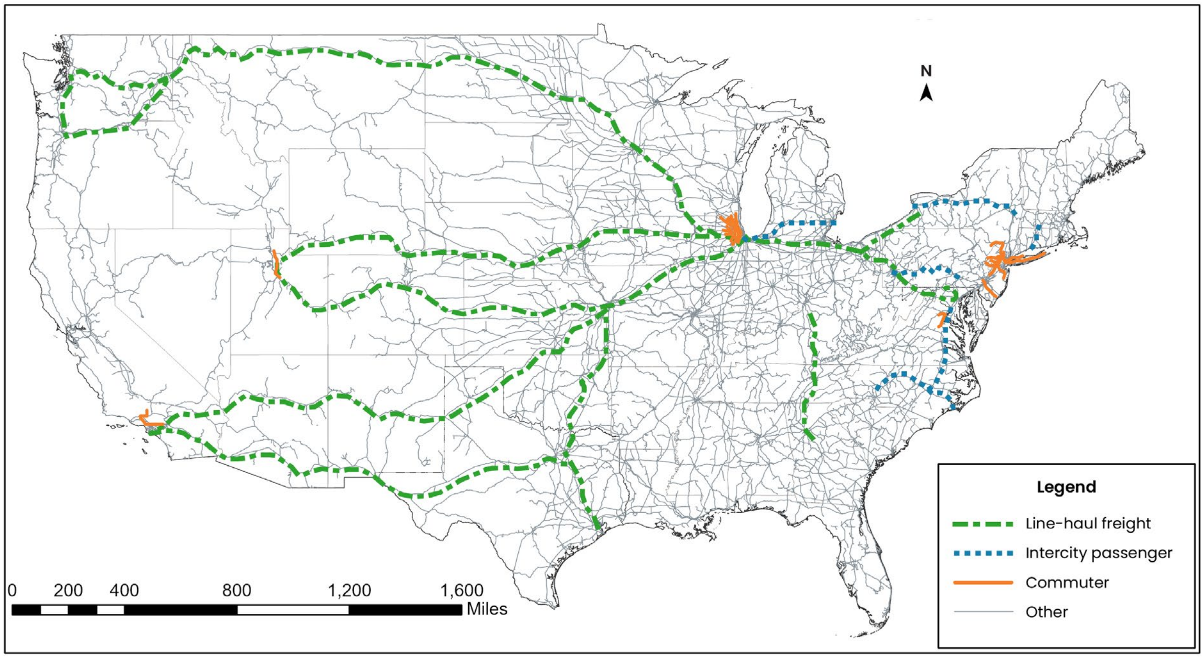



*Figure 25: Map of high-potential routes for catenary feasibility studies*

Brightline West project, which will run from San Bernardino to Las Vegas by 2028, with downtown Los Angeles.

- The **Antelope Valley Line** operated by Metrolink connects Los Angeles to Palmdale, California, and Lancaster, California.

**Key federal support opportunities:**

- DOE Vehicle Technologies Office (VTO)
- FRA CRISI Program
- DOT National Infrastructure Project Assistance (Mega) Program
- Federal Highway Administration (FHWA) Reduction of Truck Emissions at Port Facilities Program
- Maritime Administration (MARAD) Port Infrastructure Development Program (PIDP)
- FHWA National Highway Freight Program
- FHWA Carbon Reduction Program
- DOT Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program.

**Supporting actions:**

1. Support detailed techno-economic analyses and feasibility studies for catenary and discontinuous catenary systems on the priority corridors identified in this plan (DOE).
2. Host a series of rail electrification summits to identify paths forward for electrification of the core North American rail network in conjunction with transmission planning and deployment.
3. Facilitate efforts to develop a comprehensive life cycle emissions inventory for freight and intercity passenger rail, including embodied carbon and maintenance activities from non-locomotive equipment, in the rail sector (FRA/DOE).
4. Coordinate with states to integrate GHG emissions reduction goals, including rail decarbonization, into State Rail Plans (FRA).
5. Ensure that proposed rail projects are evaluated in line with the 2023 Memorandum of Understanding on

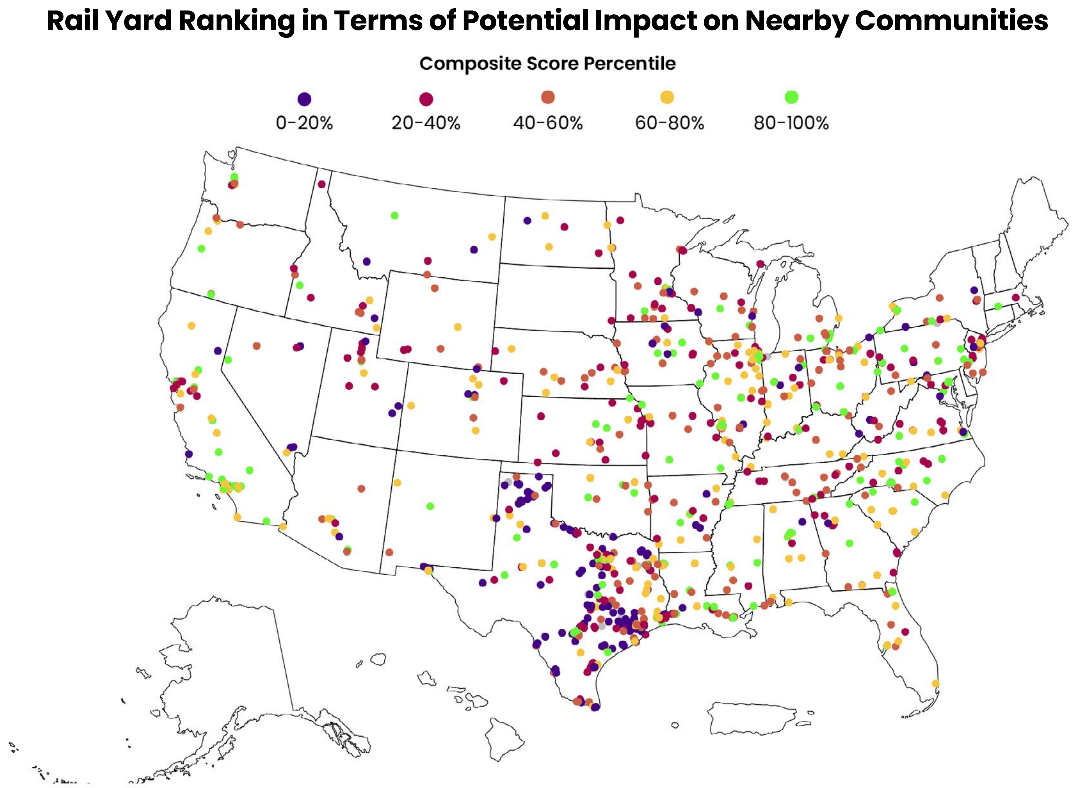



*Figure 26: Rail yard ranking in terms of potential impact on nearby communities. Higher scores represent higher probable health hazards for local population. Source: NREL analysis*

[Uniform Standards on Tribal Consultation](#) (all governmental entities).

6. Work in consultation with Tribes to identify best locations to reroute rail lines when tracks or other infrastructure—such as catenary—are upgraded or installed (DOT/railroads).

## 6.2 Support Deployment of Zero-Emission Locomotives and Air Pollution Reduction Measures in Rail Yards

Criteria pollution and hazardous air pollutants from locomotives represent a health hazard to the populations living near rail activities.[155] Whereas most carbon emissions come from long-distance freight rail, the oldest locomotives tend to operate in rail yards. Achieving the national zero-emission freight system goal[156] will require a sizable mode shift of freight from roads to rails. This mode shift should be accompanied—if not preceded—by rail yard decarbonization, drayage electrification, and other harm-reduction measures to decrease the burden on already overburdened communities.

Working in collaboration with organizations representing rail-adjacent communities, each rail yard was ranked in terms of its potential health impacts on nearby communities (displayed in Figure 26).[m] The full results for all Class I rail yards in the contiguous United

m The cumulative score for each rail yard (displayed information) was generated by summing the percentile ranking of the rail yard for each of the following attributes of each rail yard: estimated $NO_x$ emissions, estimated $PM_{10}$ emissions, estimated $PM_{2.5}$ emissions, number of other rail yards within 5 miles, population density of the adjacent census tract, asthma rates in the adjacent census tract (PLACES), heart disease rates in the surrounding census tract (PLACES), number of schools within 2 miles, and cumulative burden score in the adjacent census tract, as defined by the DOE disadvantaged communities explorer, which includes 38 variables, including socio-economic status and environmental hazards from EJScreen.

States are listed in Appendix C. The results of this analysis provide data to inform assessments for prioritizing rail yards, to determine suitable and appropriate yards for zero-emissions funding and partnerships where investments in rail yards could have significant public health improvements. The proposed Technology Innovation for Energy-Efficient Railyards (TIEER) Initiative will further the identification and implementation to reduce emissions from rail yards and help create the nation's first zero-emissions rail yard, in consultation with community expert stakeholders. FRA is developing a framework for determining criteria to select rail yards for a full zero-emission transition to also include criteria such as: number and age of locomotives currently operating, the contribution of yard equipment to the region's pollution levels, total costs for transitioning from fossil fuels, access to electricity and charging infrastructure, and public-private partnership (PPP) opportunities.

Idling is a major contributor to emissions in and around rail yards. Replacing diesel locomotives with zero-emission technology is one way to eliminate localized air pollution. However, short-line and regional railroads may not have sufficient revenues to replace a $100,000 secondhand locomotive from a larger railroad with a brand-new $4 million+ zero-emission locomotive. To reduce air pollution in the immediate term, railroads can employ affordable strategies to reduce emissions from idling, such as:

- Installing a plug-in-style shore power system that uses electrically powered heaters and pumps to warm water/oil (only reduces emissions when at the home location)
- Educating and training locomotive operators and maintainers and/or manually shutting off locomotives
- Installing auxiliary power units that use a small diesel engine to run a heating unit (doesn't need to be plugged in, and saves fuel at home and on the road)
- Detecting and fixing air-brake leaks to prevent air compressors from running unnecessarily
- Replacing locomotive starter batteries with chemistries with greater capacity, such as lithium-ion, that do not have limited daily restarts.

**Key federal support opportunities:**

- FRA CRISI Program
- EPA Diesel Emissions Reduction Act (DERA) Program
- EPA Greenhouse Gas Reduction Fund
- EPA Environmental and Climate Justice Block Grants (Community Change Grants) program
- EPA Climate Pollution Reduction Grants (CPRG) program
- MARAD PIDP
- FHWA Congestion Mitigation and Air Quality Improvement Program (CMAQ).

**Supporting federal actions:**

- Work with environmental justice community leaders, Tribes, and railroad workers to create a strategy to significantly reduce pollution burdens from concentrated rail yard operations that pose significant health and safety risks (DOE, DOT, EPA, and the Department of the Interior).
- Facilitate efforts to develop a comprehensive locomotive inventory for all Class I, II, and III and industrial locomotives, including tier, years in operations, locations, routes, and hours of operation for each locomotive to understand public health impacts and estimate life cycle emissions (FRA/DOE).
- Develop data pipeline to track impacts on disadvantaged communities from deployment of zero-emissions rail equipment and upstream infrastructure development efforts, e.g., jobs created or lost, criteria air pollutant and noise

exposure, hazardous waste spills, cost of rail transport (DOT, EPA, and DOE).

- Conduct rail yard case studies of a transition to zero emissions, in coordination with railroads and other stakeholders (FRA).
- Develop or establish new intermodal or railroad facilities (FRA).

### 6.3 Support Research and Deployment of Battery and HFC Locomotives Through a Public-Private Partnership

The technologies for fuel cells and battery locomotives are rapidly changing. Testing these locomotives in real-world conditions is critical for gathering long-term performance data to assess their viability for decarbonization of different rail market segments over the long run. Access to capital for manufacturers and their customers is key to establishing an early market for zero-emission technologies. Once production scales increase and associated costs decrease, the economic barrier to adoption will be significantly reduced, if not eliminated. In the interim, it will take coordinated effort between government, industry, and private funders to accelerate deployment of these emerging technologies.

DOE will establish a public-private Rail Partnership, modeled after the 21st Century Truck Partnership, to bring together rail operators, manufacturers, utilities, workers, and state and federal agencies under one platform to (DOE/DOT):

1. Develop zero-emission locomotive and accompanying infrastructure deployment targets for the rail sector.
2. Address and reduce financial barriers to OCS.
3. Address and reduce technical barriers to battery, electric, and hydrogen fuel-cell locomotives, including cost reduction, energy storage, charging/refueling infrastructure, thermal management, safety, reliability, and durability.
4. Facilitate PPPs for the research, development, testing, and adoption of zero-emission propulsion technologies, including cost reduction and performance improvements.
5. Facilitate OEMs, suppliers, utilities, labor, communities with environmental justice concerns, and infrastructure companies to come together to develop plans to decarbonize routes and rail yards.

**Key federal support opportunities:**

- DOE Hydrogen and Fuel Cell Technologies Office (HFTO)
- DOE VTO
- DOE Bioenergy Technologies Office (BETO)
- FRA Transportation Technology Center (TTC) research and testing facility
- FRA Office of Research, Data and Innovation
- DOE **Loan Programs Office (LPO)** Advanced Technology Vehicles Manufacturing (ATVM) Loan Program.

**Supporting federal actions:**

- Fund research and deployment of HFC locomotive refueling as well as the production and availability of clean hydrogen (DOE).
- Develop guidelines and best practices to deploy zero-emissions locomotive technologies (FRA).
- Develop safety standards for zero-emission locomotives, tenders, refueling equipment, and storage facilities, including standards to reduce collisions at rail crossings from quieter technologies (FRA).
- Develop freight interoperability and safety standards (FRA):
    - Battery electric locomotives, tenders, and chargers
    - Hydrogen storage facilities, fueling infrastructure, and locomotives
    - Sustainable liquid fuels such as renewable BD.

## 6.4 Expand Access to Intercity and Intracity Passenger Rail Service

Through the enactment of BIL in 2022, Congress provided a historical level of funding to improve, create, and expand intercity passenger-rail service across the United States. Making safe, reliable, affordable, and convenient nationwide intercity passenger-rail service would promote the shift to a more efficient mode of transportation and provide access to communities that previously may not have had intercity rail as an option for travel. These programs seek to maximize access to passenger rail services and connect major population hubs to provide a rail option to more people. To select specific corridors for new rail service, the FRA initiated the Corridor ID Program, whereby applicants submit proposals for new rail service (this program also selects applicants for improvements or extensions to existing service). FY 2022 corridors were selected to conduct service development plans, including seven corridors for further study for new HSR service (depicted in red in Figure 27). The California HSR project connecting San Francisco to Los Angeles expects to begin service on the initial segment of the route in 2030 to 2033. Brightline West expects to provide HSR service from Rancho Cucamonga, California, to Las Vegas, Nevada, by 2028. The Corridor ID Program identified 34 corridors for further study for conventional intercity passenger rail service (depicted in blue in Figure 27). From this initial list, FRA has committed to initiating three new corridors by 2035, pending results of the service development plans.

**Key federal support opportunities:**

- FRA CRISI Grant Program
- FRA Federal-State Partnership for Intercity Passenger Rail (FSP) Grant Program
- FRA Corridor ID Program

**Corridors Selected for the FY22 Corridor ID Program for New High-Speed and Conventional Intercity Passenger Rail**


**Disclaimer**: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. It does not represent an on-the-ground survey and represents only the approximate relative locations of cities, project locations, and routes. Cities shown on the map are added to provide geographic reference and are not intended for any other purpose. Every effort has been made to ensure the highest accuracy of all data on this map, but some errors can occur.

*Figure 27: Corridors selected for the FY22 Corridor ID Program for new high-speed and conventional intercity passenger rail*

**Transit Commute Share in 2019 of Transit Cities with High Potential for Mode Shift to Rail**

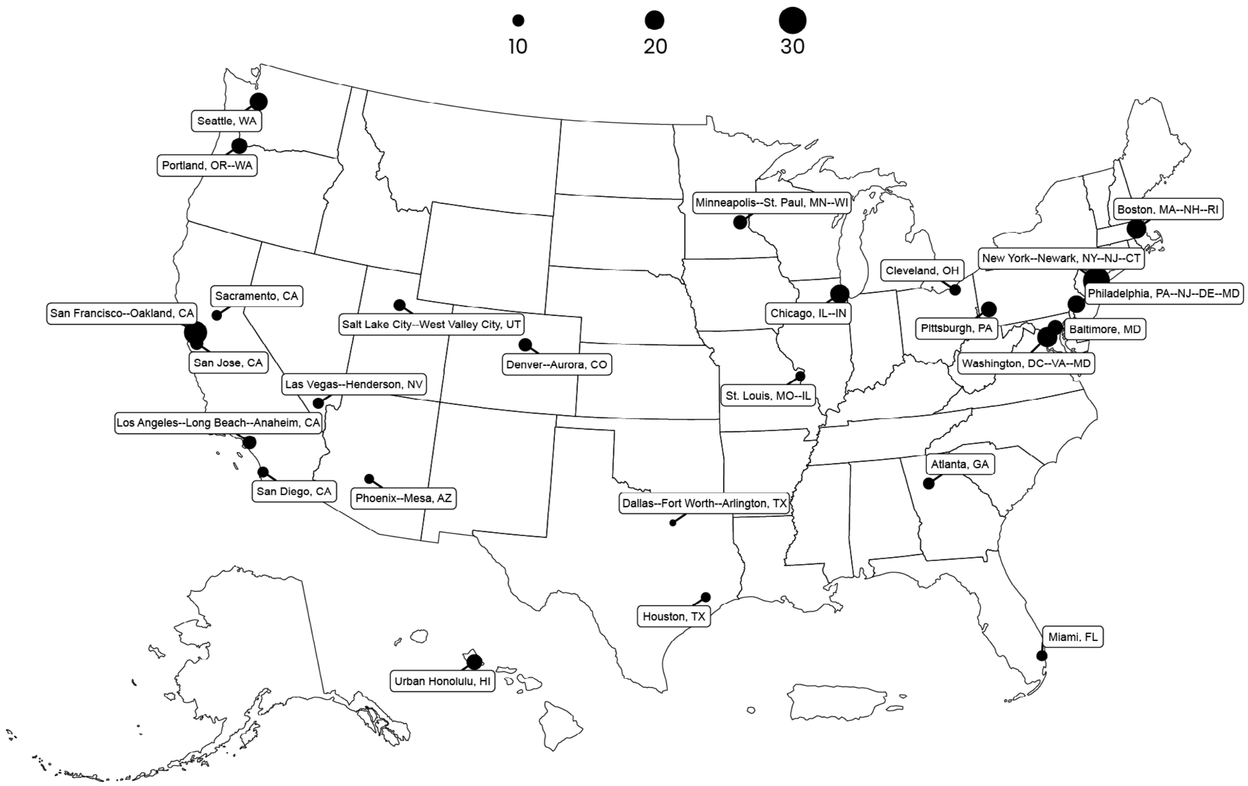



*Figure 28: Transit commute share in 2019 of transit cities with high potential for mode shift to rail*

- FRA Restoration and Enhancements Grant Program
- FRA Railroad Crossing Elimination (RCE) Grant Program
- DOT RAISE Grant Program
- DOT Mega Program.

Figure 28 displays the top 26 transit cities in the United States—those that either had 50 million transit trips in 2019 or had already invested in at least 50 miles of heavy rail or light rail—and the percentage of all commuters (excluding those that work at home) that primarily used transit in 2019.[157] These areas represent promising locations for reducing GHG emissions through mode shift. This graphic highlights two opportunities for reducing GHG emissions through mode shift to transit: (1) increasing transit investments to build capacity in places where transit has been demonstrated to be successful (higher transit mode share), and (2) increasing transit investments to bring transit ridership up to the level of other peer cities (lower transit mode share).

**Key federal support opportunities:**

- Federal Transit Administration (FTA) Capital Investment Grants Program
- FTA Rail Vehicle Replacement Program
- DOT Railroad Rehabilitation and Improvement Financing (RRIF) program
- U.S. Department of Housing and Urban Development (HUD) Pathways to Removing Obstacles to Housing (PRO Housing) grants
- HUD Land Use Reforms and Off-Site Construction Research Grants
- HUD Section 108 Loan Guarantee Program of Community Development Block Grant program

- DOT Transportation Infrastructure Finance and Innovation Act (TIFIA) program
- FHWA Surface Transportation Block Grant (STBG) program
- DOT Neighborhood Access and Equity Grant Program.

## 6.5 Expand Access to Freight Rail to Reduce Overall Energy Requirements in the Freight System and Revitalize

Transparent assessment and characterization of the social costs and potential benefits of mode shift will support policymakers and planners to make the infrastructure investments and regulatory policies necessary to harmonize truck and train transport to increase benefits, reduce harms, and accelerate our pace to accomplishing the national goal of a zero-emissions freight system. Studies have demonstrated that VMT and fuel taxes are not enough to compel shippers to utilize rail rather than trucks, even for long hauls.[158] Any mode shift of truck freight to rail greater than 3%–4% will require more than taxes on trucking.

The most congested rail yards as measured by cargo dwell time are Barstow, California; Atlanta, Georgia; North Platte, Nebraska; West Colton, California; Chicago, Illinois (all yards combined); and Kansas City, Missouri.[159] These rail yards represent priority areas to target for system and terminal efficiency improvements to ensure that freight rail remains an attractive shipping mode. It is important to make sure that efficiency improvements to terminals do not increase the impact of the terminal or yard on nearby communities.

Starting in the 1960s and accelerated by the passage of the 1980 Staggers Rail Act, the Class I railroads transitioned away from owning their own freight-rolling stock, eventually transitioning to the creation of railcar leasing companies. Today, 60% of active railcars are owned by railcar pooling or leasing companies. Even though certain energy-efficiency measures have high returns on investments, there are few incentives for individual operators and manufacturers to deploy them, as they cannot be assured that they will realize the benefits of their investment. After the deregulation of rail shipping prices in the Staggers Rail Act, the Class I railroads created a two-tier shipping rate. These rates are the carrier rate, where a railroad-owned railcar is used to move the good, and the shipper rate, using a non-railroad-owned railcar to ship the good. To take advantage of more aerodynamic railcars, railroads will need to update their pricing models with cheaper rates for customers who use more aerodynamically efficient railcars. Support is needed to provide a mechanism to share in the investments and benefits of energy-efficiency measures.

Opportunities to reduce energy needs should be explored while prioritizing safety and without deteriorating service quality. This plan identifies specific levers to improve efficiency, with particular emphasis on reducing air-brake leaks and reducing aerodynamic drag with features such as those deployed today in long-distance trucking.

**Key federal support opportunities:**

- DOT RRIF program
- FRA CRISI Program
- FHWA Reduction of Truck Emissions at Port Facilities Program
- FHWA National Highway Freight Program
- DOT Nationally Significant Multimodal Freight and Highway Projects (INFRA) program
- FRA Office of Research and Development
- FHWA Carbon Reduction Program.

**Supporting actions:**

1. Support levers to increase train energy efficiency, specifically focusing on strategies that will reduce total energy demands regardless of the powertrain, while prioritizing safety.
2. Conduct site-specific analyses to identify cost-effective levers to reduce bottlenecks at key rail terminals and increase throughput on the rail system.
3. Support research to identify locations that would support freight and passenger rail transport but lack connective infrastructure, including, but not limited to:
    a. Increase industrial access to rail by adding (or reviving existing) spur lines.
    b. Coordinate scheduling between short line and Class I railroads to increase origin-to-destination reliability across the entire system to compete with long-haul trucking.
    c. Build out a carload-centric system in which import and export docks have direct rail access.
    d. Use interline partnerships to address unserved or underserved lanes that require interchange.
    e. Invest in transload and industrial parks with rail-centric offerings to bring the freight to the railroad.
    f. Penetrate shorter-haul intermodal lanes where market share is low for rail.
    g. Explore opportunities to leverage roll-on/roll-off models, where feasible.

## 6.6 Rail-to-Grid Integration: Coordinate Utilities, Railroads, Communities, and Other Stakeholders on Rail-Electrification Planning, and Grid Decarbonization and Reliability

Connecting currently isolated regional-power markets is critical to achieve overall U.S. decarbonization goals and ensure long-term grid resilience. The rail network has the potential to support grid resilience and decarbonization by a) transporting energy storage along the rail network, and b) sharing the rail ROW for transmission lines.

Electric utilities will be key for the decarbonization of rail transportation and should be involved in planning for rail electrification from the outset. While there would be a need to construct new electric power infrastructure to serve electrified freight-rail lines, electric utilities could see the new loads from freight trains as a business opportunity. Energy storage connected to electric rail catenary, as well as wayside energy storage systems, could be located at passenger train stations and along freight railroads. Under utility control, these distributed energy-storage systems could be charged at off-peak hours, provide power to the local distribution grid during periods of peak power grid demand, and provide ancillary services such as voltage and frequency support, reactive power, or aid integration of distributed solar-energy systems. A sufficient level of energy storage along a rail line could provide backup power in case of a local or regional power outage.

**Integrating electricity and transportation system plans and investments is critical to building a national network of decarbonized fueling infrastructure.**

Integrating planning and investment spanning the transportation and electricity systems is essential to accelerating the cost-effective build-out of robust fueling infrastructures across the United States. The increasing demand for electricity, directly for EVs, and indirectly to produce low carbon fuels, requires a commensurate response that accelerates the accommodation of these new end uses into electricity policy, utility regulation, and the deployment of needed energy infrastructure.

A refreshed approach to electric grid planning that extends the utility regulatory compact to also include the transportation end uses critical for meeting climate change goals will help ensure the timely provision of reliable, safe, affordable, and resilient electric services. Stakeholders will need to account for new transportation loads, advanced grid-management technologies, and new business models into demand forecasts and operating practices. These demand forecasts could extend the time and geography included in their capital infrastructure plans beyond those located in their service territory to reflect and support the achievement of regional or national transportation goals. Importantly, collaboration will facilitate public and private financing to ensure that new decarbonized fuels and electricity are affordable for drivers, fleets, and utility customers alike.

The federal government's longstanding R&D efforts with private industry to advance grid technology has commercialized to enable mass customer adoption of distributed energy resources operating in smarter and increasingly flexible utility systems. Deployment programs in BIL and incentives enabled by IRA are accelerating this modernization. **Across the country, while these deployments help lay the foundations for transportation decarbonization, decision-making among the private sector, civic organizations, and the public sector at local, state, and federal levels that guide electric system regulation, planning, and operation must be harmonized to construct fuel networks benefitting all Americans.**

In BIL, Congress recognized the importance of federal leadership in these cross-sectoral planning needs in establishing the Joint Office of Energy and Transportation (JOET),[n] and acknowledged the importance

n 23 U.S. Code § 151 established JOET to facilitate collaboration between DOE and DOT to study, plan, coordinate, and implement zero-emission transportation and related infrastructure. Among other responsibilities, JOET is charged with technical assistance related to the deployment, operation, and maintenance of electric vehicle supply equipment (EVSE) and hydrogen fueling infrastructure; vehicle-to-grid integration; data sharing to inform the network build-out of EVSE and hydrogen fueling infrastructure; studying national and regional needs to support the distribution of grants; electric infrastructure and utility accommodation planning in transportation ROWs; and studying, planning, and funding for high-voltage distributed current infrastructure in the ROWs of the Interstate System and for constructing high-voltage and/or medium-voltage transmission pilots in the ROWs of the Interstate System; among other activities.

of coordinated multi-state freight corridor compacts[o] to develop and finance infrastructure while considering the needs of a broad range of stakeholders. BIL also established a new planning standard for transportation electrification[p] under the Public Utility Regulatory Policies Act (PURPA), enabling initial utility actions to expand rates, charge infrastructure and investment, and recover associated costs to support EVs. Although these provisions provide initial resources, their distinct frameworks and scopes suggest that the U.S. response to customers' growing calls to timely construct their contributions toward a broader, nationwide decarbonized fueling infrastructure network that is economical and resilient will come from integrated transportation, along with energy planning and investment.

In implementing the action plans, utilities and transportation planners—working with their regulatory authorities, alongside public and private sector entities, and in coordination with DOE and DOT—should incorporate local, regional, and national multimodal mobility goals into energy infrastructure plans by:

- **Extending planning horizons.** Utilities and states can continue to implement EV charging programs, specifically considering more recent technology assessments and the associated energy demanded by long-term decarbonization goals, thereby identifying cost-effective electricity system investments that support timely service to and energization of customers.
- **Expanding end-use forecasts.** This allows utilities to plan for and serve anticipated electricity demand from non-road transportation end uses including maritime, rail, and aviation—and associated efficiency measures.
- **Contributing to the national network.** State DOTs and utilities can coordinate to better understand and serve the electricity demand associated with inter-utility, interstate, and interregional transportation to deploy electricity delivery infrastructure that meets the needs of regional and national interest-mobility corridors timely and cost-effectively.
- **Improving efficiency of capital investments.** Utility and transportation planners can seek information from stakeholders to understand needs, priorities, and issues to maximally leverage private-sector financing and other means to reduce the marginal costs of delivering electricity to transportation end-uses.

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o Multi-state freight corridor planning, authorized under 49 U.S.C. § 70204, recognizes the right of states, cities, regional planning organizations, Tribes, and local public authorities (including port authorities) that are regionally linked with an interest in a specific nationally or regionally significant multi-state freight corridor to enter into multi-state compacts to promote the improved mobility of goods. These compacts allow for projects along corridors that benefit multiple states, assemble ROWs, and perform capital improvements and employ a variety of financing tools to build projects, including with support of DOT.

p 16 U.S.C. § 2621 amended PURPA to establish a requirement wherein each state's utility ratemaking authority, electric utilities, and nonregulated electric utilities shall consider measures to promote greater transportation electrification. The standard describes measures that states and utilities could pursue, including the establishment of rates that promote affordable and equitable options for light-, medium-, and heavy-duty EV charging; improvements to the customer experience, including reducing charge times; acceleration of third-party investments; and appropriate recovery of the marginal costs of delivering electricity to EVs and charging. The provision allows states with existing EV rate standards to be exempt from the standard and permits states that decline to implement the standard to publish a statement of reasons.

**BNSF Southern Transcon and UP Sunset Routes Overlaid on Solar Irradiance**

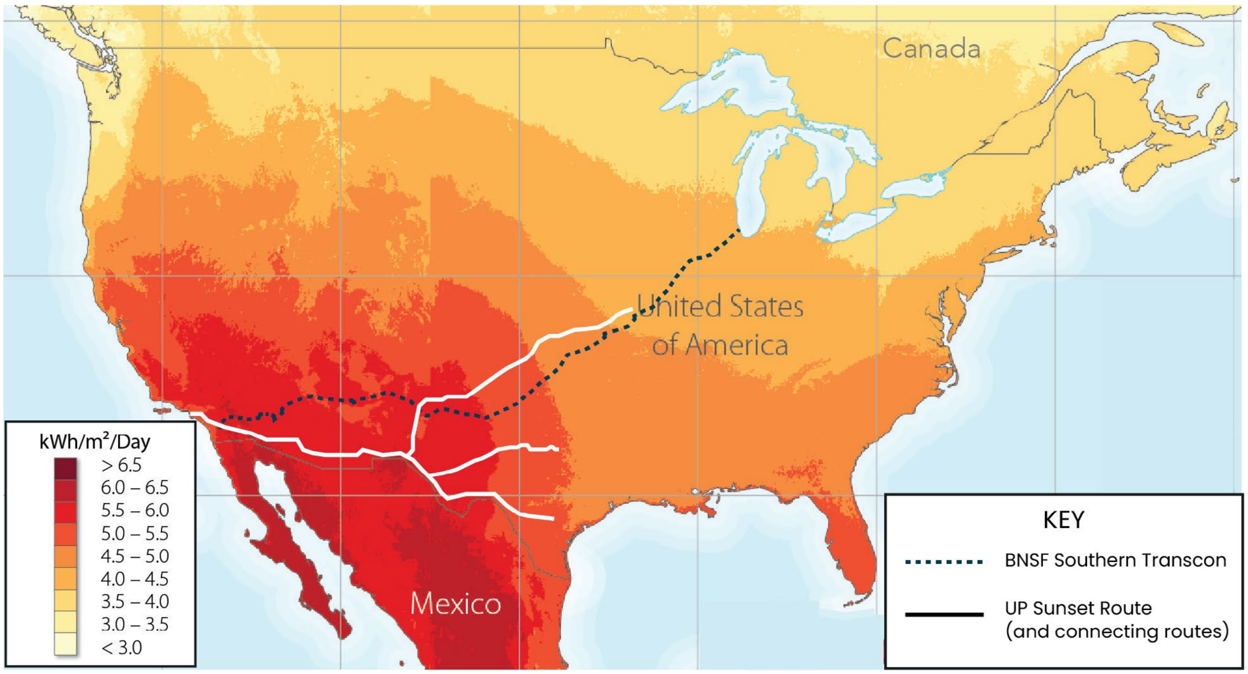



*Figure 29: BNSF Southern Transcon and UP Sunset routes overlaid on solar irradiance*

To aid in the electrification of railroad operations, colocation of alternating current transmission in rail corridors should be encouraged over high-voltage direct current (HVDC) transmission. Rail electrification, whether implemented through overhead catenary or battery locomotives, requires frequent connections to high-voltage transmission. Connections to HVDC for OCS or battery chargers would be highly uneconomical, because they will require frequent, expensive, semi-conductor-based power converters. Connections to high-voltage alternating current transmission will be more economical, as these connections will use transformers.

Many of Amtrak's and SEPTA's 25-hertz grids are in rail ROW. Historically, other electrified operators (such as the North Shore Line) ran overhead transmission above their catenary wires. The Champlain Hudson Power Express project will use 108 miles of rail ROW for buried transmission lines to bring power from Quebec, Canada, to New York City. One private project, the SOO Green Line, is making progress toward building a buried transmission line under a 350-mile rail line from Iowa to Illinois. A PPP model, in which railroads allow transmission lines on their ROW and in return receive a portion of the electricity to propel their trains, could jointly benefit railroads and energy providers. Furthermore, such infrastructure could be coordinated with electrification goals for the on-road sector to increase utilization of infrastructure and share the costs across more operators. Large-scale electric energy storage systems can also be co-located with the grid-connected "traction power substations," which power electric rail lines, benefiting the reliability of both the power grid and the rail sector.[160] Four possible pathways are under consideration for potential synergies between rail electrification and grid planning:

- Buried transmission with battery-energy storage banks at key charging locations
- Overhead transmission and catenary
- Buried transmission and catenary
- Overhead transmission and battery storage.

The Federation of American Scientists notes that areas with high potential for wind and solar generation in the Great Plains and the greater Southwest area overlap with existing rail along BNSF's Southern Transcon and UP's Sunset Route (Figure 29).[161] These two routes represent areas for greater study, though access to renewable energy is only one consideration for planning systems for rail-based mobile energy storage or collocating transmission in rail ROW.

**Key federal support opportunities:**

- DOE Advanced Research Projects Agency – Energy (ARPA-E) Vision OPEN 2024 program
- DOE LPO Energy Infrastructure Reinvestment program.

**Supporting actions:**

1. Host a series of rail-electrification summits that bring together community stakeholder experts, railroads, workers, and utilities to identify challenges and solutions between transmission planning and rail electrification (DOE, DOT, JOET, the National Academy of Sciences, and the Climate Policy Office).
2. Develop guidelines and best practices for use of rail ROW for electric transmission (DOE).
3. Engage Tribes to identify opportunities for community benefits, such as community-generated renewable energy that could be sold to the railroads, so that the benefits of rail decarbonization are not restricted to the railroads (DOE/DOT).
4. Work in consultation with Tribes to identify locations to reroute rail lines when tracks or other infrastructure—such as catenary—are upgraded or installed (DOT/railroads).
5. Complete a national assessment to identify priority corridors for collocating transmission lines and rail ROW, including abandoned rail corridors (DOE/DOT).

**Table 10: Greenhouse Gas Emissions Reduction Goals for Railroads**

| Railroad | Scope | Target Value | Type | Base Year | Target Year |
|---|---|---|---|---|---|
| Amtrak | 1+2+3 | 40% | Absolute | 2010 | 2030 |
| | 1+2+3 | Net-zero | Absolute | NA | 2045 |
| BNSF Railway | 1+2 | 30% | Absolute | 2018 | 2030 |
| Canadian National (CN) | 1+2 | 43% | Intensity | 2019 | 2030 |
| | 1+2+3 | 90% | Absolute | 2019 | 2050 |
| Canadian Pacific Kansas City (CPKC) | 1+2+3 | 36.9% | Intensity | 2020 | 2030 |
| CSX Corporation | 1+2 | 37.3% | Intensity | 2014 | 2029 |
| Norfolk Southern (NS) | 1+2 | 42% | Intensity | 2019 | 2034 |
| Patriot Rail | 1+2 | 42% | Absolute | 2020 | 2030 |
| Union Pacific (UP) | 1+2 | 26% | Absolute | 2018 | 2030 |
| | 1+2+3 | 100% | Absolute | 2018 | 2050 |

## 6.7 Support Transitional Technologies That Leverage Existing Equipment to Reduce Near-Term Emissions

Planning and building-out the connective infrastructure needed for a zero-emission rail network will take time. This plan identifies opportunities to reduce carbon emissions while still leveraging the relative efficiency and long lifetimes of existing locomotives. Transitional technologies that can support long-term decarbonization while delivering emissions reductions today include hybrid diesel-electric locomotives, retrofits of locomotives to run on zero-emission propulsion with diesel backup power, and alternative fuels for ICEs, including sustainable liquid fuels and hydrogen. The use of these technologies for rail is expected to increase in the near-term and then decrease over time as adoption of electrification and zero-emission technologies increases. Between now and 2035, transitional technology options should be deployed, where feasible, to reduce emissions from locomotives that still have many years of useful life.

All Class I railroads and one Class II railroad have science-based targets for near-term GHG emissions reductions. Some also have long-term net-zero GHG emissions goals. These commitments aim for a 26–43% reduction in GHG emissions from a pre-COVID baseline year by 2030. Private investment in both zero-emission infrastructure and transitional technology will be critical to achieving these near-term emissions reductions.

**Key federal support opportunities:**

- DOE VTO funds research on the use of hydrogen in internal-combustion engines
- DOE's BETO funds work on the feasibility of alternative sustainable liquid fuels for use in the rail sector
- FRA Office of Research and Development.

**Supporting actions:**

1. Support demonstrations of locomotive retrofits to run on battery tenders while keeping diesel engines as a backup (DOE/DOT).
2. Support scaling of sustainable liquid-fuel production (DOE BETO).
3. Support development and deployment of hybrid battery electric locomotives in locations where charging infrastructure is not readily available (all).

# 7. CROSS-CUTTING STRATEGIES TO SUPPORT TRANSPORTATION DECARBONIZATION

The railroad industry's development and deployment of zero-emission technology will require more than just scaling up infrastructure and equipment. It will require investments in the railroad workforce, who will be necessary to the transition to achieve net-zero emissions by 2050. Engagement with international partners—especially Mexico and Canada, whose rail networks connect to that of the United States—is essential to share best practices for deployment and coordinate large-scale infrastructure strategies. Finally, this plan identifies potential policies and regulations that could support rail decarbonization as well as overall transportation decarbonization and efficiency.

## 7.1 Developing and Supporting the Workforce

With a long history of collective bargaining, the railroad industry has one of the highest unionization rates of any U.S. industry, resulting in strong compensation and benefits for many railroad employees. Several unions represent different crafts and classes of railroad workers, and coordination with these labor unions is important to help current employees adapt during the transition to low- and zero-emission operations.

As described throughout this report, various pathways are available to the railroad sector for decarbonization, including all or a combination of electrification, battery-powered locomotives, hydrogen locomotives, locomotives powered by the latest biofuels, or lower-emission diesel locomotives. As the industry pursues these pathways, workers who operate, maintain, build, and support railroads will need to be supported to help make the transition smooth, as the current and future rail workforce will have a key role in implementing those technologies.

For example, IBEW, Brotherhood of Maintenance of Way Employes Division of the International Brotherhood of Teamsters (BMWED-IBT), and the United Electrical, Radio and Machine Workers of America, support electrification of the U.S. rail network. BMWED-IBT and IBEW install and maintain the overhead catenary on Amtrak's NEC between Washington, D.C. and New York and from New York to Boston, respectively. IBEW includes a component on catenary construction and maintenance in their journeyman curriculum to better prepare electricians for an electrified transport future.

By incentivizing the decarbonization of freight rail, the United States may also be able to revitalize its declining domestic locomotive industry and rebuild good jobs in both manufacturing and rail operations. Trends in the Class I freight rail industry since the mid-2010s show that widespread adoption of the precision scheduled railroading (PSR) operating model has led the Class I railroads to reduce their investment in both the amount of locomotives they run and the workforce needed to operate and maintain locomotives. Figure 30 illustrates the decline in the number of locomotives, railcars, and mechanical engineers employed in the Class I industry since the implementation of PSR in 2015.

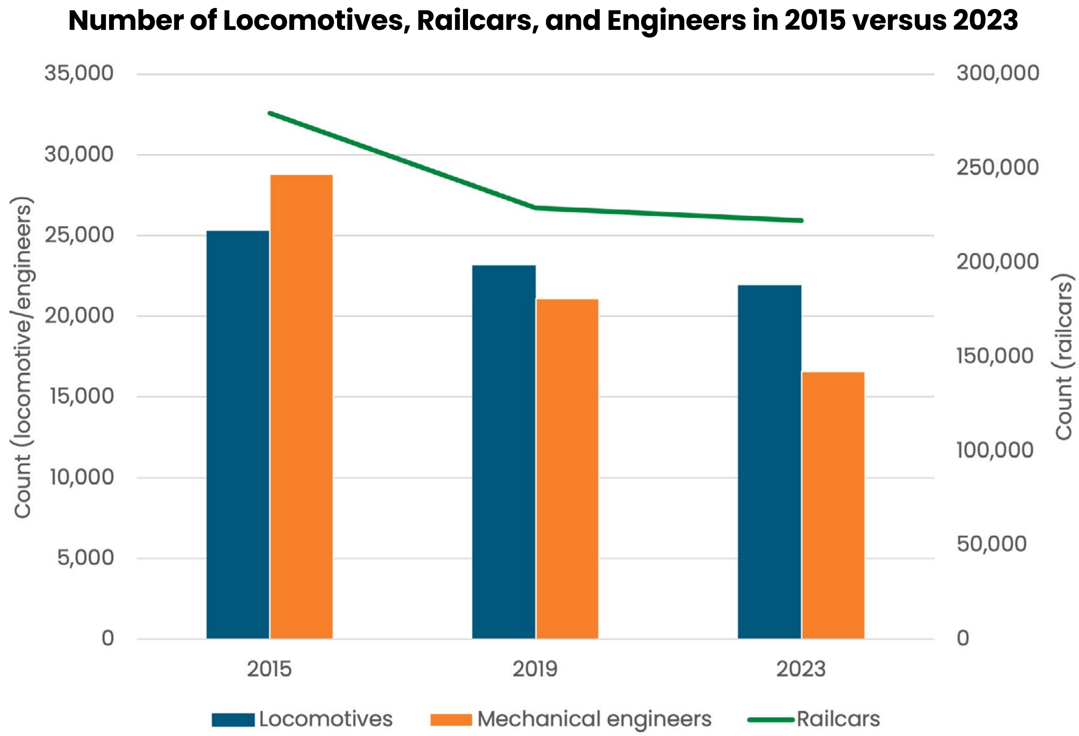



*Figure 30: Number of locomotives, railcars, and engineers in 2015 versus 2023*[162]

As the railroad industry pursues decarbonization and the adoption of new technologies, it will need a skilled workforce to help deploy these new technologies, supported by training and apprenticeship programs. For example, around 2008, Wabtec Corporation's Erie, Pennsylvania, facility produced up to 1,000 locomotives per year—but a decline in domestic demand for locomotives forced the facility to shrink from 4,000 workers to 1,400 in 2023. One study found that the production of 1,000 new battery electric locomotives per year at Wabtec would lead to 2,600–4,300 new unionized jobs within Wabtec (depending on whether batteries are made onsite); 3,060–5,100 jobs throughout the vicinity of Erie County; and 9,860–14,960 across the overall U.S. economy.[163]

Several unions have historically been involved in the upgrade and retrofit of freight diesel locomotives to meet higher-tier EPA locomotive emissions standards. For instance, workers represented by the International Association of Machinists and Aerospace Workers, the International Association of Sheet Metal, Air, Rail and Transportation Workers, and the International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers play critical roles in replacing diesel engines with newer ones that meet higher emission standards and upgrading structural components required by the new engines. Additionally, workers represented by the National Conference of Firemen and Oilers, and the Service Employees International Union, are responsible for fueling locomotives, and thus adoption of new fuels, like biofuels or hydrogen, will involve changes to their work and skills. Similarly, those who operate trains need to be familiar with how fuel-saving technologies or changes to locomotive or rail-car aerodynamics impact safe train handling.

**Workforce Development**

Federal agencies have a powerful role in encouraging workforce development through their funding mechanisms. For example, FRA's CRISI Grant Program can be used for railroad workforce development and training activities, providing opportunities for labor unions, public agencies, short-line and regional railroads, and others to deploy federal grants to develop and execute workforce training and apprenticeship programs related to railroad safety, efficiency, and reliability. The FY 2025 budget proposes to dedicate $5 million of CRISI funding for this eligibility.

A National Railroad Institute would provide railroad workers opportunities to develop and maintain the skillsets and tools needed to deliver and maintain a 21st-century rail network. The president's FY 2025 budget proposes to dedicate $5 million to establish and maintain a National Railroad Institute to develop and conduct training and education programs for both public- and private-sector railroad and railroad-related industry employees (including the railroad manufacturing, supply, and consulting fields). This Railroad Institute would provide railroad industry employees with similar opportunities to their counterparts in highways and transit who have benefited from decades of departmental leadership in workforce training and technical assistance, delivered through the FHWA's National Highway Institute and the FTA's National Transit Institute.

FRA's Rail Research and Development Center of Excellence (CoE) Grant Program makes funding available to establish a center to advance R&D efforts that seek to improve the safety, performance, and sustainability of freight, intercity passenger, and commuter rail. Created by BIL, the grant program supports establishing and maintaining a CoE as well as providing funding for certain projects, such as basic and applied research, evaluation, education, workforce development, and training efforts related to safety, project delivery, efficiency, reliability, resiliency, and sustainability of urban-commuter, intercity high-speed, and freight rail transportation.

Additionally, commuter railroad employees may benefit from the Transit Workforce Center (TWC), the first FTA-funded technical assistance center to directly support public-transit workforce development. Its mission is to help transit agencies recruit, hire, train, and retain a diverse workforce needed now and in the future. The TWC is geared towards developing frontline transit workers' skills and recruiting workers to transit careers through various programs, such as apprenticeships and partnerships.

Beyond federal funding, opportunities exist to support a transitioning workforce. The United States has only three specialized university railroad transportation and engineering programs, located at the University of Illinois, Michigan Technological University, and Penn State Altoona. A handful of community colleges also provide railroad degrees, such as Sacramento City College and Johnson County Community College. In contrast, the European Union has nearly 40 university programs in railroad transportation and engineering. A full-scale railroad transportation and engineering program should be initiated in colleges and universities throughout the United States.

Moreover, railroads can work with OEMs and labor unions to fund and develop structured apprenticeship programs to ensure that railroad employees have received the necessary skills to work on new technology. Equipment manufacturers can sponsor training and apprenticeship programs to support a railroad workforce that has the knowledge to operate and maintain their equipment (e.g., the Cummins apprenticeship program). Another strategy to ease the transition to new technology is to keep the operator interface as similar to diesel-electric locomotives as possible. For example, certain OEMs are keeping the internal controls with battery electric locomotives to minimize the training burden on employees.

**Support**

Federal investments that support this transition, including grants funding infrastructure projects to improve or expand the freight and passenger rail network, represent opportunities and an

obligation to create a generation of good-paying jobs with the choice to join a union, confront the climate crisis, equitably grow the economy, and reinforce America's global competitiveness. The Fiscal Year 2022–2026 USDOT Strategic Plan provides a roadmap for how we will implement this once-in-a-generation investment to create a transportation system that works for every American.

FRA's notice of funding opportunity (NOFO) for the CRISI Grant Program incorporates such goals through considering how projects will create good-paying, safe jobs with the free and fair choice to join a union—including through the use of a project labor agreement (PLA)—promote investments in high-quality workforce development programs, adopt local and economic hiring preferences for the project workforce, and promote local inclusive economic and entrepreneurship programs. Similarly, the CoE NOFO describes the intention to use projects resulting from the program to support the creation of good-paying jobs with the free and fair choice to join a union, and the incorporation of strong labor standards and training and placement programs, especially registered apprenticeships, in project planning stages. FRA also intends to use the CoE Program to support wealth creation, consistent with the DOT Equity Action Plan through the inclusion of local inclusive economic development and entrepreneurship such as the utilization of low-income business enterprises, minority-owned businesses, women-owned businesses, or 8(a) firms.

Moreover, Congress has long recognized that federal infrastructure investments are inextricably linked with the U.S. workforce. As part of the competitive grants programs that could be used to help decarbonize and expand railroad service across the country, FRA requires that workers benefit from those investments, not be harmed by them. For instance, certain projects funded by FRA grants—like CRISI or FSP—require that the livelihoods of frontline workers impacted by those projects are not worsened. Known for decades to railroad workers as 4R Act protections, they have evolved to adapt to modern grant programs that support infrastructure projects that improve, expand, and create intercity passenger rail service and improve the safety, efficiency, and reliability of freight and passenger rail, among others. These protections are required by statute, described in DOT NOFOs, and will continue playing an important role in supporting the current and future railroading workforce.

Similarly, federal investments in our nation's rail network sustain and grow domestic manufacturing and the millions of jobs it supports through both the long-standing Buy America requirements and the Build America Buy America requirements created under BIL. Buy America standards require a project that receives federal dollars to ensure that 100% of the iron, steel, and/or manufactured components are domestically manufactured. Continuing strong Buy America standards helps to strengthen domestic supply chains, advance our nation's transportation goals, and employ American workers.

Investments in our national rail industry pose additional opportunities to benefit railroaders. For instance, the project sponsors for the Brightline West HSR project[164] and the CHSR project[165] have signed groundbreaking memoranda of understanding (MOUs) with 13 rail labor unions. A similar MOU was adopted in April 2024 for a third planned HSR project in California, the High Desert Intercity High-Speed Rail Corridor.[166] These MOUs represent the share goal of the project sponsors, affiliated entities, and any contractors, to ensure that workers performing traditional rail work or rail functions as part of these projects (including operating the trains, engineering, maintenance of equipment, dispatching, onboard service, clerical work, and inspection, maintenance, and repair of rolling stock) are covered under traditional federal-railroad labor laws.[q] These long-established statutes apply to the railroading workforce to provide unique benefits that historically have helped attract and retain workers to the railroading industry, developing a qualified, skilled, and experienced talent that railroads rely on. The MOUs also articulate shared goals for neutrality, recognition of a union if a majority of workers sign organizing cards, and reasonable access to unions to communicate with employees regarding joining a union. These MOUs help ensure that these HSR projects are operated and maintained by qualified, experienced workers and are consistent with executive orders that support high labor standards and promote worker power, worker organizing, and collective bargaining.[167, 168] These MOUs can serve as models for other future projects expanding intercity passenger rail.

Lastly, investments to decarbonize the railroad sector can be enhanced through PLAs. These pre-hire agreements between labor and management establish terms and conditions of employment on one or more construction projects. PLAs support good-paying job creation, increase apprenticeship, and improve local hiring goals to transition more workers into construction careers. Moreover, pre-apprenticeship requirements in PLAs help avail thousands of women, people of color, and veterans access construction-career pathways. As a result, these agreements boost local economies, address inequities, and uplift overburdened or underserved communities, while achieving substantial, direct cost savings by standardizing contract terms among various crafts. The planned operators of the CHSR and Brightline West HSR projects have signed PLAs for construction, having already created 13,500 high-skilled construction jobs and 10,000 construction jobs and career opportunities, respectively. A PLA was also approved for a third planned HSR project in California, the High Desert Corridor Joint Powers Authority. These PLAs are consistent

q These include, for example, the Railway Labor Act, 45 U.S.C. 151 et seq., Railroad Retirement Act of 1974, 45 U.S.C. 231 et seq., and the Railroad Unemployment Insurance Act, 45 U.S.C. 351 et seq.

with the Feb. 4, 2022, executive order and can serve as a model for other similar projects.[169]

Rail decarbonization presents an opportunity to inspire today's workers to pursue careers in the clean economy, upskill workers into higher-paying jobs supporting climate priorities, meet the needs of American companies looking for skilled workers, and ensure that Americans in every corner of the country have a role in tomorrow's economy. This will require a commitment to addressing systemic barriers to employment in addition to strong collaboration between partners at all levels of government and across sectors. With this spirit of innovation and collaboration, the federal government looks forward to working together to seize this transformative opportunity for the United States.

The DOT Grant Application Checklist for a Strong Transportation Workforce and Labor Plan assists applicants for competitive grants to describe their efforts to create good-paying jobs and workforce opportunities for those jobs.

**Supporting Actions**

The following actions will help ensure that rail workers and manufacturing workers are protected during the transition to lower- and zero-emission locomotives and trains and the greater utilization of technology like overhead catenary:

1. Fund and support workforce development and training programs, including for zero-emission technologies, especially in disadvantaged communities (FRA).
2. Support apprenticeship programs, such as the ones Metra and Amtrak have done (U.S. Department of Labor/DOT).
3. Bring trade skills back to high-school curricula and expand vocational schools for welding, machining, electrical, and engineering programs (states in collaboration with railroads).
4. Create a National University Rail Center (FRA and University of Illinois).

## 7.2 Supply Chain and Manufacturing

Investments in scalable vehicle- and component-manufacturing processes and supply chains are a core part of the pathway toward lowering zero-emission locomotive costs and capturing economic and jobs benefits. Zero-emission locomotives are manufactured at very low volumes today, resulting in higher costs due to a lack of economies of scale. Upstream components used in the production of fuels and infrastructure—such as hydrogen electrolyzers and sustainable liquid fuel technologies—will also need to scale manufacturing to enable competitive costs. Investments in domestic BEV manufacturing and supply chains will be crucial to maintain U.S. economic security and global competitiveness and can substantially invigorate the U.S. manufacturing and clean energy industries, while building partnerships with key allies can fill in remaining supply gaps that cannot be filled domestically.

Access to critical supplies, such as batteries, power controls, and cabling, will directly determine the potential to scale up zero-emission technology. Dedicated efforts to increase the efficiency of battery production and to recycle critical materials will lower capital costs and reduce environmental and social consequences of mining. While current global lithium-ion demand is about 300 GWh, global battery manufacturing capacity is expected to reach 6,500 GWh by 2030,[170] with 1,200 GWh annually in the United States.[171] Lithium-ion battery pack prices hit a record low of $139/kilowatt-hour (kWh) in 2023.[172] Argonne forecasts lithium-ion battery pack prices to be $123/kWh by 2026 and $100/kWh by 2030.[173] Lithium iron phosphate tends to be the favored battery chemistry for rail applications (based on cost, energy density, and durability),[174] though some companies are starting to look to sodium-ion chemistry to reduce reliance on lithium.

Objectives for scaled zero-emission locomotives, components, and infrastructure manufacturing set by DOE and others include the following:

- Ensuring access to reliable sources of critical minerals for battery production, including sustainably increasing U.S. mineral production capacity[175]
- Increasing U.S. domestic minerals processing and battery production capacity[176]
- Increasing U.S. recycling capability for critical battery materials[177, r]
- Scaling clean hydrogen production from 1 MMT per year as of 2023 to 10 MMT per year by 2030, aligned with a pathway to 50 MMT by 2050.
    - » In support of this, scaling electrolyzer production and investing in innovations to reduce stack and balance of plant costs. Manufacturing and stack innovations and economies of scale could reduce electrolyzer capital costs by more than two-thirds.[64]

**Supporting actions:**

The federal government has made substantial investments in the manufacturing and supply chain relevant to zero-emission locomotives. Near-term actions will involve the continued implementation of these investments. IRA and BIL allocate billions of USD in incentives for achieving manufacturing and supply-chain targets. These include the following incentives, financing, research, and development programs:

- $3.5 billion in funding through BIL to build a domestic supply chain for critical minerals and components, expand domestic battery-minerals and materials-processing

r Locomotive batteries can be resold for stationary purposes at the end of their useful service life; for example, this is being done in the LDV sector. NJ TRANSIT has plans to utilize their exhausted batteries from planned battery locomotives as stationary storage to charge their bus depot. Significant battery recycling efforts are underway with goals to recycle over 90% of batteries, which will also help address critical mineral supplies.

capacity, and expand U.S. advanced battery manufacturing capacity.

- The Qualifying Advanced Energy Project Credit (48C), which allocates $4 billion in tax credits for investments in clean energy manufacturing and recycling, critical materials, and industrial decarbonization, with an additional $6 billion announced. $2.5 billion in funding will be centered on designated energy communities, which include communities with retired coal mines.
- The Advanced Manufacturing Production Tax Credit (45X), which includes tax credits of up to $10/kWh for manufacturers of battery modules using battery cells, such as lithium-ion batteries.
- BD excise tax credits and income tax credits of up to $1/gallon, applying to BD, agri-BD, and renewable diesel.
- The Clean Hydrogen Production Tax Credit (45V), allocating tax credits of up to $3/kg for production of clean hydrogen (defined as hydrogen with a CI of up to 4 kg $CO_2e$ emissions per kg of production).
- The U.S. National Clean Hydrogen Strategy and Roadmap lays out the opportunity for increasing clean hydrogen[s] production from nearly zero today to 10 MMT per year by 2030, 20 MMT per year by 2040, and 50 MMT per year by 2050. Major investments made through BIL will accelerate progress towards the Hydrogen Shot, including $1 billion for a clean hydrogen electrolysis program, $500 million for clean hydrogen manufacturing and recycling activities, and $8 billion for the Regional Clean Hydrogen Hubs Program (H2Hubs), which will create networks of hydrogen producers, consumers, and local connective infrastructure to accelerate the use of hydrogen as a clean energy carrier.
- ATVM provides financing for manufacturing eligible vehicles (including locomotives) and components, including critical materials for batteries, manufacturing charging infrastructure, and modernizing facilities.

Federal investments to date in clean energy infrastructure, manufacturing, and critical components can be tracked on DOE's interactive map of nationwide investments.

## 7.3 Safety and Standards

**Federal locomotive safety standards.** Rail safety laws generally establish safety and inspection requirements for locomotives in use on a railroad line to better ensure locomotives are in proper condition and safe to operate.[t] New locomotive technology that complies with railroad safety laws is generally permitted to be used on a railroad line. FRA established a waiver process, in part, to evaluate the potential use of technology that does not comply with railroad safety laws.[u] A petition to waive safety laws must contain sufficient relevant safety data to show that granting the petition would be in the interest of safety, and other sufficient information to support the action sought, including an evaluation of anticipated impacts of the action sought; each evaluation shall include an estimate of resulting costs to the private sector, to consumers, and to federal, state, and local governments as well as an evaluation of resulting benefits, quantified to the extent practicable.[178] FRA may impose conditions on the grant of waiver if it concludes that they are necessary to assure safety or are in the public interest.[179] Use of new locomotive technology under the conditions of a granted waiver may establish a test program that permits limited use of the new technology in a safe environment on a railroad line to further evaluate the overall safety of the new technology.

s Clean hydrogen is defined as "hydrogen produced with a CI equal to or less than 2 kilograms of carbon dioxide equivalent produced at the site of production per kilogram of hydrogen produced."

t The Locomotive Inspection Act, 49 U.S.C. 20701, et seq., 49 CFR Parts 223, 229, 230, 231, 232, 238.

u 49 CFR Part 211 Subpart C.

**Equipment standards.** One hurdle to zero-emission technology adoption is the lack of industry standards, particularly with respect to charging for battery electric locomotives and catenary electrification equipment and software. Clear guidance and standards for new technologies will provide the industry with more confidence to adopt zero-emission technology. One potential model is the Megawatt Charging System, which is focused on heavy-duty battery charging for trucks and buses but could be adapted to the rail sector.

## 7.4 International Coordination

**The U.S.-Canada Rail Decarbonization Task Force.** Due to the interoperability of the North American Rail Network, the United States and Canada announced a joint Rail Decarbonization Task Force at COP28 in December 2023.[180] This task force has three specific objectives:

- Establish a joint research agenda to test the safe integration of emerging technologies, including hydrogen-powered and battery electric locomotives.
- Coordinate strategies to accelerate the rail sector's safe transition from diesel-powered locomotives to zero-emission technologies to ensure a net-zero rail sector by no later than 2050.
- Collaborate on the development of a U.S.-Canada rail sector net-zero climate model by 2025.

Such collaboration will help to streamline information exchange and accelerate dissemination of best practices from emerging technologies. Canada is working on producing an action plan to follow their Canadian rail decarbonization strategy.

**International knowledge sharing.** Knowledge transfer between nations with extensively deployed electrification infrastructure could accelerate implementation in the United States. FRA is an active member of the international rail advocacy body, the International Union of Railways (UIC), and participates regularly in its annual events and meetings. UIC facilitates technical cooperation among railroad entities across the globe while providing venues for exchanging information on best practices and subject matter expertise on a variety of rail topics. French National Railways has committed to eliminating diesel trains by 2035.[181] The U.K.'s rail system is currently 42% electrified and will phase out diesel-only trains by 2040. India electrified their rail network at record speeds and record-low costs and will achieve 100% electrification by early 2025, including freight routes with double-stack container trains. The United States can learn from the experiences of these rail electrification efforts.

## 7.5 Policy and Regulatory Opportunities

**Federal emissions standards.** The EPA's mission is to protect human health and the environment. As part of this mission, the EPA is responsible for numerous regulatory, partnership, and funding programs that seek to reduce air pollutants, air toxics, and GHG emissions from across the transportation sector, including rail. The EPA has had regulations in place to reduce criteria air pollutant emissions from new and remanufactured locomotives for 25 years, updating those standards most recently in 2008. In 2022, the EPA began work on its next tier of regulatory standards for the locomotive sector, organized in two steps.

First, the EPA has proposed and finalized revisions to its regulations that address the preemption of state and local emission regulation of locomotives and engines used in locomotives.[182] The revisions implement a policy change to no longer categorically preempt certain state regulations of non-new locomotives and engines, while retaining exclusive federal authority for the regulation of new locomotives and new locomotive engines. EPA's regulatory revisions preserve California's ability to adopt and enforce certain emission standards regulating non-new locomotives and engines, if the EPA authorizes such standards. Other states may, in turn, adopt those same California standards.

Second, the EPA has an ongoing effort engaging with a wide range of rail stakeholders including environmental justice organizations, environmental nongovernmental organizations, the rail industry, technology providers, and states to develop the next level of locomotive standards. The Clean Air Act directs the EPA to promulgate standards for new locomotives that achieve the greatest degree of emission reduction achievable, through the application of technology the administrator determines will be available for locomotives, considering the cost of applying such technology within the period of time available to manufacturers and to noise, energy, and safety factors associated with the application of such technology. As summarized throughout this document, we are standing at the threshold of significant technology change in the locomotive industry, with battery electric switcher locomotives being demonstrated and the potential for fuel cell or battery electric locomotives as part of diesel consists under development. Given these developing technologies and the mandate from the Clean Air Act, the EPA intends to develop and propose new locomotive emission regulations. To support all these actions, the EPA regularly updates the NEI and the U.S. Greenhouse Gas Inventory with the most up-to-date data and information on transportation emission sources.

In addition to the actions above, the EPA receives independent advice from technical experts through the Clean Air Act Advisory Committee (CAAAC), and on transportation issues specifically through the Mobile Source Technical Review Subcommittee (MSTRS) of the CAAAC. The EPA has engaged the MSTRS to solicit independent advice on addressing air emissions from locomotives. The MSTRS has formed a workgroup made up of representatives from a variety of organizations and backgrounds, and it will compile recommendations regarding emissions from locomotives and locomotive engines for the EPA. These recommendations will help shape any future actions from the EPA on locomotives, locomotive engines, and overall rail activities.

**Industry partnerships.** The EPA maintains numerous successful industry partnerships. The SmartWay program, for example, helps companies advance supply-chain sustainability by measuring, benchmarking, and improving freight transportation efficiency. This partnership already includes rail carriers and can serve as a model for future partnerships to improve efficiency and reduce emissions in the freight network, as well as provide a common metric for measuring and reporting GHG reductions from this sector. Further, the SmartWay Technology Program verifies idle-reduction systems that support idle-reducing behavior and can provide auxiliary power and operator comfort without the need to run the propulsion engine.

**Capital project financing.** Models from the United States and around the world provide a roadmap for how electric rail infrastructure is built, owned, and operated. Railroads, public agencies, and electric utilities could be owners of rail electrification infrastructure. Identifying viable financing models is key to the success of rail electrification.

**Infrastructure permitting.** Charging infrastructure for zero-emission technology must be designed, permitted, and constructed. Wait times vary greatly by utility and region, with some utilities able to provide rail yard charging infrastructure in a matter of a few months, and other utilities facing multi-year-long delays. Developing a streamlined permitting process for charging infrastructure could reduce wait times to deploy zero-emission technologies.

**Assured, reliable railroad funding.** Between 1949 and 2017, the federal government invested more than $2 trillion USD in the nation's highways and $777 billion in aviation. Contrast these figures with the $96 billion federal investment in Amtrak over the same time period, which amounts to less than 5% of the funding allocated to highways.[183] Assured, reliable federal investments are essential to expanding the national passenger rail network.

**Supporting actions:**

1. Complete investigation into locomotive engine emissions to support the development of new locomotive emission regulations (EPA).
2. Explore pathways to develop a program to decommission all non-zero-emission locomotives as the fleet transitions to zero emissions by 2050, to ensure that the least environmentally friendly locomotives are not used or sold to another sector or country (DOE/DOT).
3. Conduct long-term electric utility infrastructure planning to serve new demand from rail, integrated with other sectors, and inclusive of demand from

regional and national interest mobility corridors (DOE, DOT, states, and utilities).

## 7.6 Research, Data, and Analysis Needs

Railroads play a critical role in determining the future resilience, prosperity, and health of our country. Increasing rail capacity, utilization, and sustainability through investments in infrastructure, improvements in service and accessibility, and integration with a zero-emissions freight system is inseparable from national security. Research should be undertaken on models to ensure that this critical infrastructure is being operated in harmony with long-term national interests.

**Catenary electrification.** More detailed analysis of freight volumes, access to electricity, and terrain can illuminate the rail corridors to debut a discontinuous catenary approach. Much has changed since the 1983 national rail electrification study,[184, 185] and the potential for an intermittent catenary system coupled with battery and/or HFC locomotives could dramatically expand the portion of the network that can be cost-effectively electrified over a 10-to-15-year time horizon. Given that catenary is a well-established technology, research should focus on capital financing models, grid and rail sector integration, and site-specific optimization models to understand the best mix of zero-emission technologies for a given location. Particular attention should be given to how rail infrastructure needs can be coordinated with the on-road, maritime, and electricity sectors to accelerate decarbonization and maximize utilization of infrastructure, in line with the Zero-Emission Freight Corridor Strategy and national transmission planning.[v]

**Battery energy storage systems.** While battery technology is commercially available for rail yard, passenger, and short-haul operations today, the long-term operational performance and reliability of batteries is not yet known in the rail context. The most important element for understanding battery locomotives is to gather real-world operations data and observe how energy use performs over time. Research is also needed to assess operational changes that battery-only locomotives might generate for freight service. Additional research is needed to understand how batteries could complement a mostly electrified rail network to mitigate some of the challenges of catenary. Understanding how batteries used in the rail sector could support grid resilience or decarbonization of other sectors, such as maritime, is also a key area of further analysis.

**Hydrogen fuel cell battery hybrid locomotive.** HFC locomotives present the most uncertainty in cost and performance of the three zero-emission options. Much research is needed to better understand the role of fuel cells in a zero-emission rail system, particularly line-haul uses. In the near term, these research priorities focus on developing $LH_2$ tenders to increase the range of HFC locomotives, improving hydrogen refueling times, and doing detailed risk assessments for the use of hydrogen in locomotives and nearby communities. As HFC locomotives begin deployment in the United States, collecting and sharing data on operational costs and maintenance will be critical to assessing their long-term viability for use in the rail sector.

**Energy efficiency.** In some cases, the benefits of energy efficiency investments are well known, but not necessarily returned to the investor. In other cases, the fuel savings potential needs additional study to identify the highest benefit-cost investments in energy efficiency. Research is needed to evaluate which individual energy savings measures deliver the greatest benefits without compromising safety or labor rights.

v **DOE ARPA-E** funds four rail sector modeling tools through their LOCOMOTIVES program that could be leveraged to inform rail decarbonization investments, such as optimal siting for intermodal fueling infrastructure, priority corridors for catenary electrification, or optimal train energy use en route (e.g., when to charge and discharge batteries). In 2023, ARPA-E announced a continued effort to increase the energy efficiency of the freight system with its INTERMODAL program, aimed to optimize freight movement across on-road, maritime, and rail.

This research will also inform where different emerging technologies may become viable.

**Community impacts of zero-emission locomotive deployment.** Operational data is needed to calculate and track actual emissions from rail yards and rail activities near populated areas. Case studies for specific rail yards have been completed, but a national assessment of the health impacts from rail yards is needed. Grid reliability in communities already overburdened with environmental hazards can be a compounding hazard. Research is needed to understand how deployment of zero-emission technology in these communities can improve—rather than strain—local electric grid resilience.

**Rail-to-grid integration.** The feasibility and total costs and benefits of these approaches need to be examined in anticipation of rail electrification and national transmission planning to be able to develop detailed infrastructure plans in time to achieve net-zero emissions by 2050. Detailed research is required to assess where opportunities for coordination will yield the greatest benefits to rail electrification and grid resilience.

**Convenient and affordable access to efficient passenger and rail service.** We lack methodology and accessible tools to assess the total social benefits of mode shift for passenger and freight rail. Furthermore, we do not have many real-world examples of which levers lead to the greatest mode shift. The most recent analysis on capacity constraints in the rail network was conducted in 2007.[186] Multiple questions must be answered to be able to assess investments in rail decarbonization compared to investments in infrastructure that would generate a shift from less-efficient modes to rail. Research is needed to define and assess the full costs and benefits (beyond GHG emissions) of a shift from trucks to freight rail, as well as the distribution of those

impacts. Research is also needed to understand the barriers to choosing rail as a shipping mode.

## 7.7 Equity and Environmental Justice

Low-income communities have been and continue to be disproportionately exposed to noise and PM from diesel combustion from rail activities.[187] Diesel locomotives are a significant source of $NO_x$ and particulate emissions, making rail a priority sector for zero-emission technology to reduce criteria air pollutant emissions alongside GHG. Figure 31 shows EPA-estimated $NO_x$ emissions from Class I railroad activities in U.S. counties with the highest emissions correspond to the routes with the highest volumes of rail traffic.[188] Air pollution from locomotives is estimated to cause approximately 1,000 premature deaths annually in the United States.[189] Reducing emissions from the rail sector can lead to meaningful health benefits.

While detailed analyses on the specific impact of rail activities on public health for all rail yards are not yet available, case studies on specific rail yards illustrate the importance of addressing criteria pollution from locomotives. For example, a study using air-pollution monitors sited around on-road and non-road emissions sources in the Ironbound area of Newark, New Jersey indicated that over 70% of the emissions to which residents are exposed come from rail activities, even though rail yard emissions represent a very small portion of the pollution directly emitted within the boundary of the study area.[190]

Reducing rail emissions is particularly important for communities with environmental justice concerns that are potentially overburdened with pollution. Rail yards are often co-located with communities with environmental justice concerns and impose adverse health impacts on those communities.[191] For example, PM from diesel exhaust could lead to asthma and respiratory illnesses and worsen heart and lung disease, especially in children and the elderly, as well as potentially increasing cancer risk.[192, 193]

Under BIL, the FRA CRISI Program carries the administration priority to consider how the benefits

**Class I Line-Haul Oxides of Nitrogen (NOx) Emissions by County**

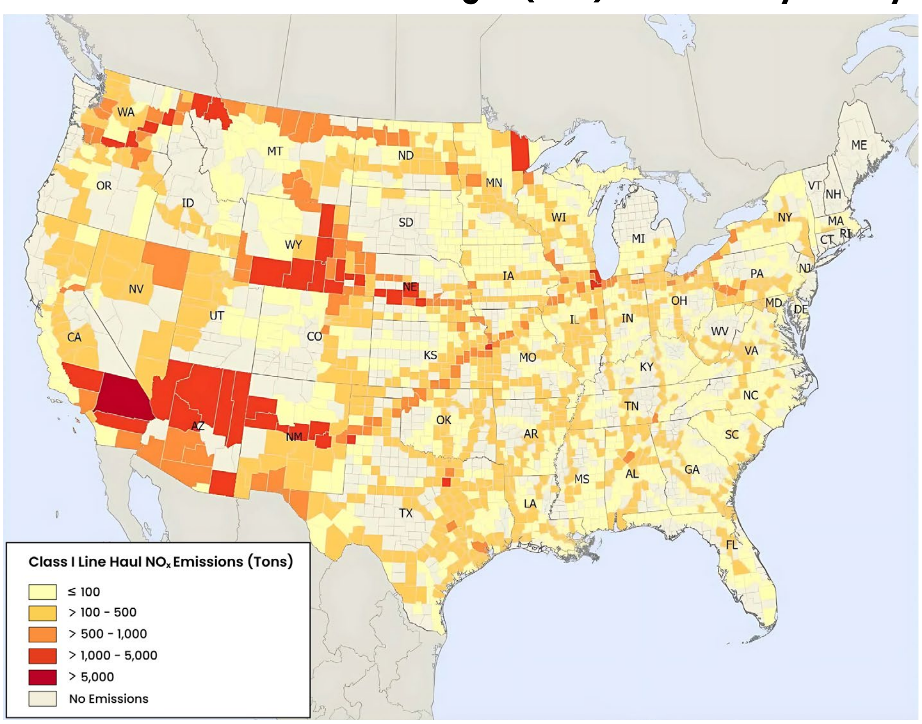



*Figure 31: Class I line-haul oxides of nitrogen ($NO_x$) emissions (tons) by county in 2020*

and potential burdens of a project may impact communities with environmental justice concerns. Two new tools can help applicants estimate the impacts of their proposed rail projects. The FRA Justice40 Rail Explorer is an open-access map of transportation-disadvantaged communities, rail facilities, and air pollution that can be used to prioritize federal and external investments in those areas.[194] The FRA Locomotive Emissions Comparison Tool can help applicants estimate the emissions benefits of cleaner technology and prioritize locomotives for deployment to alleviate the most overburdened communities.

## 7.8 Tribal Sovereignty and Right-of-Way Justice

Railroads have a complicated legacy in the United States, and the construction of the Transcontinental Railroad had devastating consequences for migrant laborers and Indigenous peoples.[195] From destroying sacred lands to spreading disease, railroads caused irrevocable damage to the land and the people who depended on that land before the arrival of settler-colonialism.[196, 197] In an attempt to begin rectifying some of these harms, one Class I railroad invited an Indigenous Advisory Council to propose a framework for reconciliation, but the two groups were not able to come to an agreement and the council resigned.[198] Any progress toward rail decarbonization would benefit from an acknowledgment by the railroads of the injustices they have caused to Tribal Nations. Railroads should commit to working with Tribal Nations to redress existing injustices to the extent possible.

In their 2006 letter to DOE, the Affiliated Tribes of Northwest Indians Economic Development Corporation[199] wrote: "Indian Tribes have historically been 'colonized' by energy companies; meaning that energy companies have a history of entering Indian reservations, often with federal government support … Indian Tribes as sovereign governments are now seeking to change the paradigm of their relationships with energy companies, and to become full partners in the use of their resources. Land is one of those resources, and as such, Tribes do prefer to use their land resources to become part of energy development rather than a victim of energy development." To ensure that Tribes are part of rail decarbonization efforts and not a victim of rail decarbonization efforts, federal agencies and railroads should engage Tribes to identify opportunities for benefits to Tribal Nations, such as community-generated renewable energy that could be sold to the railroads, so that the benefits of rail decarbonization are not restricted to the railroads.

Honoring treaty rights and addressing the grievances of Tribes is a necessary step in the process of rail electrification in particular and decarbonization generally. Many rail lines in the United States run along shorelines, conflicting with restoration of habitat for fisheries and other wildlife. Some of these rail lines also interfere with access to traditional fishing grounds and can undermine habitat for treaty-protected fisheries. Rail electrification infrastructure can provide an opportunity for ROW justice with Tribes. Curving riverside shoreline routes are not appropriate for the higher speeds of electrified rail. Moreover, in some cases, the relocation of shoreline rail lines will be necessary to mitigate the impact of rising sea levels. Moving tracks off shorelines to inland routes or higher elevations opens the way for large-scale habitat recovery for, and access to, treaty-protected fisheries.[200] If implemented in a just way, rail electrification has the potential to build broad partnership to reduce carbon emissions, connect more communities to better quality rail transportation, correct some of the historic harms of rail infrastructure on Tribal lands, and provide an opportunity to share the benefits of electrification with Tribal Nations.

As zero-emission strategies are tested and deployed, Tribal Nations should be directly engaged to ensure that historic harms are addressed where possible and that no additional harms are introduced in the name of decarbonization. The 2023 Executive Order on Tribal Self-Determination and the 2022 Memorandum of Understanding on Uniform Standards for Tribal Consultation lay the foundation for processes and guidelines by which principles of Tribal sovereignty and Tribal self-determination are upheld by federal agencies engaging in any transportation decarbonization activities. To provide dedicated support for these activities, the FRA hired its first Tribal liaison in 2023. Railroads should proactively engage with federal Tribal liaisons at all relevant agencies while exploring decarbonization pathways.
The current rail network crosses through lands belonging to many different Tribes (Figure 32). For example, decisions on where to site infrastructure, such as catenary or refueling sites, should be made in consultation with Tribes, in line with our nation-to-nation relationship, a key to upholding Tribal sovereignty.

**U.S. Rail Network by Ownership and Federally Recognized Tribal Lands**

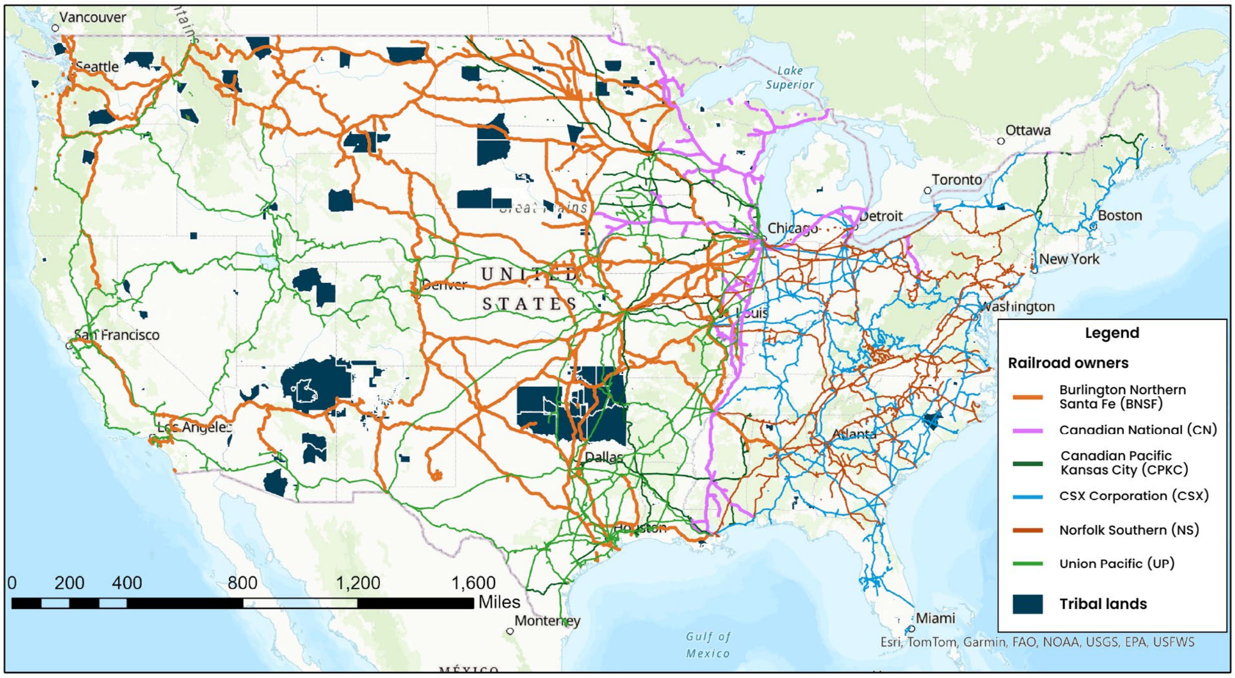



*Figure 32: U.S. Rail network by ownership and federally recognized Tribal lands*[201]

Solutionary Rail, a community organization project based in Washington state,[w] in collaboration with the Affiliated Tribes of Northwest Indians Economic Development Corporation, suggest that the following principles for energy development on Tribal lands (adopted by several Tribes) should guide rail electrification infrastructure:

- **Tribal Sovereignty and Consent** – The power of Tribes to prevent third parties from using Tribal lands without Tribal consent is a critical element of Tribal sovereignty that has been established in federal law and policy for over 200 years. The Tribal consent requirement to the use of Tribal lands should be honored and preserved.
- **Preservation of Tribal Jurisdiction** – No ROW agreement or other business arrangement that permits third-party use of Tribal land should reduce the sovereign power of a Tribe over its lands or the activities conducted on its lands in the absence of the specific consent of the Tribe.
- **Restricted Duration of Rights** – Federal law and policy should not be changed to require perpetual ROWs or automatic renewals of ROWs because such changes would deprive Tribes of management and control of their lands.[202]

CN is working on an Indigenous reconciliation plan to be published by the end of 2024.[203] Other railroads can learn from CN's process and challenges to identify best practices in collaborating with Indigenous communities along railways in the United States and Canada.

w Solutionary Rail is a project of the Backbone Campaign, a 501c3 not-for-profit organization, whose mission is to offer creative strategies and artful activism to manifest a world where life, community, nature, and our obligations to future generations are honored as sacred.

# 8. FUNDING AND FINANCING TO ACCELERATE DEPLOYMENT

New and longstanding federal programs from multiple agencies can support rail decarbonization. The programs outlined here collectively provide tens of billions of USD that can support deployment of zero-emission locomotives and supporting infrastructure, expanded access to rail services, and critical research and analysis to inform long-term infrastructure planning. In addition to these federal programs, private-sector investment will be critical to achieve a net-zero rail sector by 2050.

## 8.1 U.S. Department of Transportation

**FTA**. Authorized at $4.6 billion per year, the **FTA** Capital Investment Grants Program funds major investments in public transportation and has funded construction of numerous new or expanded rail transit systems over the years. Other key FTA programs for urban rail are the FTA's Urban Area Formula Program and the new Rail Vehicle Replacement Program. Transferring, or flexing, funds from federal highway programs to the federal transit program facilitates federal investments at the local level to improve access to rail.

**FHWA.** The FHWA Reduction of Truck Emissions at Port Facilities Program provides $400 million in competitive funding to reduce truck emissions at ports, including through port electrification and enhanced intermodal rail connections. The FHWA National Highway Freight Program has $7.2 billion for infrastructure and operational improvements that improve the efficient movement of freight and support several goals, including reducing the environmental impacts of freight movement, 30% of which can be used for freight-intermodal or freight rail projects. The FHWA Carbon Reduction Program provides $6.4 billion in formula funding for states, including for efforts to reduce the environmental and community impacts of freight movement. BIL continued the FHWA CMAQ and authorized $13.2 billion over five years to provide a flexible funding source to state and local governments for transportation projects and programs to reduce mobile source emissions and help meet the requirements of the Clean Air Act. Refueling infrastructure projects that would reduce emissions from non-road engines used in construction projects or port-related freight operations are eligible for CMAQ funding. The FHWA STBG program provides $72 billion in flexible funding that may be used to improve performance on transit capital projects and electric transit.

**DOT Office of the Secretary.** The RAISE program provides $7.5 billion for projects to improve climate and sustainability goals, including commuter, intercity passenger rail, and HSR improvements that could include electrification. The DOT Mega program **provides $5 billion** for large, complex projects, including passenger and freight rail, that provide a public safety, economic, or mobility benefit, as well as emissions reductions and increased resilience. The DOT Nationally Significant Multimodal Freight and Highway Projects (INFRA) program awards competitive grants for multimodal freight and highway projects of national or regional significance to improve the safety, efficiency, and reliability of the movement of freight and people in and across rural and urban areas. The DOT RRIF program is authorized to provide direct loans and loan guarantees to finance development of railroad infrastructure, including the acquisition, improvement, and rehabilitation of intermodal or rail equipment or facilities. The TIFIA program provides financing for infrastructure that supports TOD, intermodal connectors, and passenger rail vehicles and facilities.

**FRA.** FRA can facilitate coordination among stakeholders in the rail industry, operators, and locomotive manufacturers to test new locomotive and train sets. FRA will work with stakeholders to utilize its TTC research and testing facility to evaluate the safety of new power technologies. The FRA RDI ensures the safe, efficient, and reliable movement of people and goods by rail through basic and applied research, along with development of innovations and solutions. RDI funds research to reduce energy consumption of locomotives through waste-heat recovery and energy conversion technology. FRA's CRISI Program funds projects to improve the safety, efficiency, and reliability of freight and passenger rail, including projects that can bolster the supply chain and reduce congestion. FRA's Locomotive Replacement Initiative (LRI) under FRA's Climate and Sustainability Program provides funding to Class II and III railroads to remove high-polluting locomotives by utilizing funds allowed under Provision 16 of the CRISI Grant Program. The LRI is especially focused on replacing the least environmentally friendly locomotives from rail yards or heavily used rail corridors that affect surrounding communities.

The FRA RCE Grant Program provides funds to improve safety for at-grade crossings nationwide. Preventing blocked crossings and collisions improves safety and convenience, reduces emissions from idling, and reconnects communities. The FRA FSP Grant Program funds capital projects that expand or establish new intercity passenger rail service, improve performance, or reduce the state-of-good-repair backlog, including privately operated intercity passenger-rail service. BIL provided $36 billion in supplemental appropriations for the program. The FRA Restoration and Enhancements Grant Program provides $250 million to initiate, restore, or enhance intercity rail-passenger transportation. The FRA Corridor ID Program will identify and develop plans for new or improved intercity passenger rail services.

**MARAD.** BIL provided MARAD's PIDP with $2.25 billion for projects that reduce or eliminate port-related criteria air pollutant or GHG emissions, including port electrification or electrification master planning; development of port or terminal micro-grids; idling reduction infrastructure; worker training to support electrification technology; and EV charge or hydrogen refueling infrastructure for locomotives that service the port and related grid upgrades.

## 8.2 U.S. Environmental Protection Agency

The EPA administers numerous programs that fund zero-emission transportation equipment and technology, including locomotives, using funds allocated by the 2022 IRA and other sources. The Greenhouse Gas Reduction Fund provides $7 billion for low-income communities to deploy zero-emission technology or carry out programs for emissions reductions.

The EPA's long-standing DERA Program can also provide funding to reduce emissions from locomotives, including replacing older ones with newer zero-emission technologies. Since 2008, DERA has typically provided $60 million annually to fund grants and rebates that protect human health and improve air quality by reducing harmful emissions from diesel engines. IRA provided an additional $60 million to DERA to reduce diesel emissions from a variety of types of equipment, including those serving goods-movement facilities, such as rail yards, emphasizing areas not in attainment with air quality standards, and low-income and disadvantaged communities.

The EPA Environmental and Climate Justice Block Grants (Community Change Grants) program **provides $3 billion** for community-led air-and-other pollution monitoring, prevention, and remediation, and investments in low- and zero-emission and resilient technologies and related infrastructure and workforce development that help reduce GHG emissions and other air pollutants. The new CPRGs provide $250 million for the costs of developing plans to reduce GHG air pollution, and directs the EPA to make such a grant to at least one state agency, air pollution control agency, municipality, or Tribe in each state. Each plan should include programs, policies, measures, and projects that will achieve reductions. CPRG Implementation Grants provide another $4.6 billion for competitive grants to implement projects to help achieve targets set under CPRG planning grants targets.

## 8.3 U.S. Department of Energy

The **Office of Energy Efficiency and Renewable Energy (EERE)** VTO Off-Road, Rail, Maritime, and Aviation program funds research and analysis of low- and zero-emission rail technologies. EERE HFTO conducts research to lower the cost of hydrogen and fuel cells and is also funding work on infrastructure requirements for a hydrogen-based rail network. EERE BETO primarily assesses the potential availability of feedstocks, develops feedstock-handling logistics scenarios, and de-risks technologies to convert those feedstocks into biofuels and end-uses of biofuels.

**ARPA-E.** ARPA-E's Vision OPEN 2024 has made funding available for research to investigate potential for "energy superhighways," including along the rail network.

**LPO** finances large-scale, multi-faceted energy infrastructure projects in the United States and provides first-of-a-kind projects and other high-impact energy-related ventures with access to debt capital that private lenders cannot or will not provide. LPO's team can deploy billions in debt capital to scale up manufacturing of zero-emission locomotive technologies. The ATVM program can support the reequipping, expanding, or establishing of U.S. manufacturing facilities for fuel-efficient, advanced technology vehicles (including locomotives) and qualifying components. Under the Title 17 Clean Energy Financing Program, LPO can provide loan guarantees for projects in the United States that support clean-energy deployment and energy infrastructure reinvestment to reduce GHG emissions and air pollution. The Energy Infrastructure Reinvestment program can provide up to $250 billion in debt financing for projects that retool, repower, and replace energy infrastructure that has ceased operation; remediate air pollutants from energy infrastructure; remediate environmental damage to energy infrastructure; and produce electricity.

## 8.4 Department of Housing and Urban Development (HUD)

The HUD PRO Housing grants provide funding to communities that are seeking to remove barriers to affordable housing, such as restrictive regulatory, zoning, or land-use policies and outdated procedures or permitting processes. Many HUD programs have minimum energy standards in the form of green building certifications, which encourage active and public transportation along with compact urban design. Similarly, 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.

The HUD Land Use Reforms and Off-Site Construction Research Grants provide communities with up to $3 million to assess the potential for off-site construction methods to increase housing supply. The increased density associated with greater housing supply is more conducive to high-quality public transit and active transportation networks, which in turn leads to a reduction of VMT.

The interagency Thriving Communities Network provides disadvantaged communities with technical assistance and resources to support equitable development. The Thriving Communities Technical Assistance program is designed to improve integration of transportation and housing in infrastructure planning and implementation. The Section 108 Loan Guarantee Program of the Community Development Block Grant Program provides communities with a source of low-cost, long-term financing for economic and community development projects. Section 108 can fund housing and infrastructure projects.

# 9. CORE MILESTONES AND INDICATORS OF PROGRESS

Based on the current and anticipated state of locomotive technology, interim milestones are developed to mark a path to a net-zero-emission rail sector by 2050. Deployment is the main priority for rail yard operations, given the large and immediate benefits of reducing air pollution from rail activities near heavily populated areas and the commercial availability of zero-emission locomotives for these purposes. In addition, real rail-network experiences with battery switchers will undoubtedly provide useful experiences for deployment of batteries in line-haul locomotives. Once fuel cell and battery locomotives are analyzed, demonstrated in real-world operating conditions, and better understood in the context of national infrastructure planning, including hydrogen storage and distribution and multi-sector transmission planning, the synergies between these three technologies will become clearer.

Core milestones to support the seven key actions identified in this plan include the following:

1. Initiate detailed feasibility studies for catenary and discontinuous catenary electrification for line-haul freight, intercity passenger, and commuter rail service on high-potential routes.
    - By 2024, initiate study on full costs and benefits of catenary electrification for the priority list of freight corridors identified in this plan, in close collaboration with community expert stakeholders.

- By 2025, finalize short-list of rail corridors to conduct detailed feasibility studies—including grid impacts—for long-term catenary electrification planning.
- By 2026, conduct detailed feasibility studies for electrification planning for shortlist of corridors.
- By 2026, develop a national electrification plan that identifies where catenary works, where discontinuous catenary works, and where other solutions may be required.
- By 2027, support advancement of the first discontinuous catenary commuter rail system in the United States.
- By 2027, develop a national railroad workforce plan to ensure that a sufficient workforce is available for installation and maintenance of new catenary and other infrastructure out to 2050 and beyond.
- By 2030, develop a national freight and passenger rail plan identifying necessary infrastructure upgrades, such as grade separations and yards, to achieve modal shift goals.

2. Support deployment of zero-emission locomotives and idling-reduction measures in rail yard operations to improve public health.

    - By 2025, develop a framework for identifying suitable rail yards for full zero-emission transition in collaboration with industry, community partners and experts, and state and local officials.
    - By 2030, target deployment of at least 200 zero-emission locomotives in rail yards where they would offer high-potential health benefits.

3. Support development and deployment of battery electric and HFC locomotives for line-haul rail operations with a Rail Research and Development PPP.

    - By 2025, initiate a PPP with industry, community, academic, governmental, international, and other key stakeholders (DOE).
    - By 2027, deploy at least 10 battery and/or HFC locomotives in line-haul operations.

4. Expand access to intercity and intracity passenger rail service.

    - By 2026, increase transit ridership in the top transit cities back to at least 100% of 2019 levels.[204]
    - By 2033, initiate or advance project development of new electrified HSR service on at least two corridors.
    - By 2035, initiate intercity passenger rail on at least three new corridors.[205]
    - By 2035, eliminate 100% of Amtrak's state of good repair (SGR) backlog of Amtrak-owned fleet, Americans with Disabilities Act station compliance, and non-NEC infrastructure.[206]
    - By 2035, reduce the NEC SGR backlog by 60% and reduce corridor-wide trip times.[207]
    - By 2040, at least double intercity passenger rail ridership from 2019 baseline.[208]

5. Expand affordable access to freight rail to accommodate projected increases in freight shipments and reduce overall energy requirements in the freight system.

    - By 2026, complete a national assessment of potential mode shift from projected increase in truck and plane tonnage to rail (DOE).
    - By 2026, support measures to improve freight train aerodynamics, without compromising safety.

6. Rail-to-grid integration: Coordinate utilities, railroads, communities, and other stakeholders on rail electrification planning and grid decarbonization and reliability.

    - By 2024–2026, host a series of rail electrification summits that bring together community stakeholder experts, railroads, workers, and utilities to identify challenges and solutions between transmission planning and rail electrification.

  - By 2026, complete a national assessment to identify priority corridors for collocating transmission lines and rail ROW (DOE).

7. Leverage existing assets by supporting transitional technologies to reduce near-term emissions.
    - By 2026, support demonstration of diesel-electric locomotive retrofits with battery tenders.
    - Until 2035, deploy transitional technology options, where feasible, to reduce emissions from locomotives that still have many years of useful life.

Indicators should be defined to track nationwide progress on decarbonization of and affordable access to freight and passenger-rail services. This section provides a list of potential metrics to begin tracking progress. Some of these data are already collected, and some of them will require new data pipelines.

**The following indicators can track progress toward decarbonizing the rail sector and decarbonizing the transportation system more broadly:**

- **Clean technology deployment**
    - Share of locomotives using zero-emission technologies (National Transit Database [NTD])
    - Deployment of zero-emission locomotives (CARB Zero Emissions Rail Project Dashboard)
    - CI of freight and passenger-rail modes
    - Share of ton-miles transported by zero-emission technology
    - Share of passenger-miles transported by zero-emission technology
    - Miles of catenary deployed
    - Amount of federal funding dedicated to rail decarbonization (deployment and R&D)
    - Number of zero-emission rail projects financed.
- **A just and equitable transition to rail decarbonization**
    - Number and percent of zero-emission locomotives deployed in disadvantaged communities (CARB dashboard and Justice40 Rail Explorer)
    - Changes in environmental impacts on communities near rail activities (e.g., noise, jobs, particulate emissions)
    - Transit and passenger-rail affordability
    - Jobs created in disadvantaged communities from rail decarbonization strategies.
- **Efficient rail and transport systems**
    - Energy intensity of Class I freight rail (BTS Table 4-25)
    - Energy intensity of intercity passenger rail (BTS Table 4-26)
    - Energy intensity of commuter rail (NTD Annual Fuel and Energy)
    - Average dwell time at rail yards and terminals (Surface Transportation Board)
    - Energy intensity of all freight cargo across trucks, ships, and rail
    - Freight rail mode share by distance band (BTS Table 1-50, FAF).
- **Convenient access to rail**
    - Number of new intercity passenger corridors created
    - Amount of federal funding dedicated to expansion of affordable rail (deployment and R&D).

# 10. CONCLUSION

## 10.1 A Holistic, Comprehensive Approach

Transportation is the largest source of GHG emissions and the second-largest household expense. Decarbonizing the transportation sector is integral to achieving a net-zero-emissions economy that benefits all communities. Moving toward zero transportation GHG emissions is not only critical to tackling the climate crisis, but the accompanying transformation of the passenger and freight mobility systems toward sustainable solutions and technologies will save lives and improve the quality of life of all Americans. It will increase U.S. competitiveness, decrease household costs, increase economic growth, reduce pollution, and increase accessibility and community opportunities.

The historic MOU signed by DOE, DOT, EPA, and HUD in September 2022 initiated collaboration across the federal government to rapidly decarbonize transportation. The agreement recognizes the unique expertise, resources, and responsibilities of each agency, setting the foundation for solutions that are more innovative and far-reaching than any of the agencies could achieve independently.

The *U.S. National Blueprint for Transportation Decarbonization* (Blueprint), the first step in this collaboration, created a national vision for a decarbonized transportation system. The Blueprint embraced five core principles (initiate bold action; embrace creative solutions across the entire transportation system; ensure safety, equity, and access; increase collaboration; and establish U.S. leadership) to serve as the foundation for all strategies.

The Blueprint provided a holistic, system-level approach to decarbonizing the transportation sector, proposing actions that address all aspects of transportation GHG emissions, from land-use

patterns and development to design of individual vehicles. The Blueprint focused on three key strategies—Convenience, Efficiency, and Clean—which will support and complement each other in achieving the goals of the Blueprint (Figure 33).

As part of the clean strategy, the Blueprint committed to developing specific mode-based action plans for the light-duty vehicle, medium-/heavy-duty vehicle, rail, maritime, off-road, and aviation sectors, to chart pathways to accomplish this complex task over the next three decades. The modal action plans propose near-, mid-, and long-term actions to achieve net-zero emissions in each of the different modal sectors by 2050. This phased approach leverages the historic federal BIL, Pub L. No. 117-58 (2021), and IRA, Pub. L. No. 117-169 (2022), funding; encourages deployment of scalable, market-driven technologies; provides industry and stakeholders with certainty about transforming the transportation sector; recommends planning and proposes policy opportunities at multiple levels of government; and promotes expanded research, development, demonstration, and deployments to support innovative approaches to decarbonize the transportation sector, including new technologies and fuels. The phased actions across all modes are summarized below.

**National Blueprint for Transportation Decarbonization Strategies**

## The Blueprint's Five Principles

- Initiate bold action
- Embrace creative solutions across the entire transportation system
- Ensure safety, equity, and access
- Increase collaboration
- Establish U.S. leadership

1

### Increase Convenience

by supporting community design and land-use planning at the local or regional level that ensure that job centers, shopping, schools, entertainment, and essential services are strategically located near where people live to reduce commute burdens, improve walkability and bikeability, and improve quality of life...

...Because every hour we don't spend sitting in traffic is an hour we can spend focused on the things and the people we love, all while reducing GHG emissions.

2

### Improve Efficiency

by expanding affordable, accessible, efficient, and reliable options like public transportation and rail, and improving the efficiency of all vehicles...

...Because everyone deserves efficient transportation options that will allow them to move around affordably and safely, and because consuming less energy as we move saves money, strengthens our national security, and reduces GHG emissions.

3

### Transition to Clean Options

by deploying zero-emission vehicles and fuels for cars, commercial trucks, transit, boats, airplanes, and more...

...Because no one should be exposed to air pollution in their community or on their ride to school or work and eliminating GHG emissions from transportation is imperative to tackle the climate crisis.

*Figure 33: National Blueprint for Transportation Decarbonization Strategies*[209]

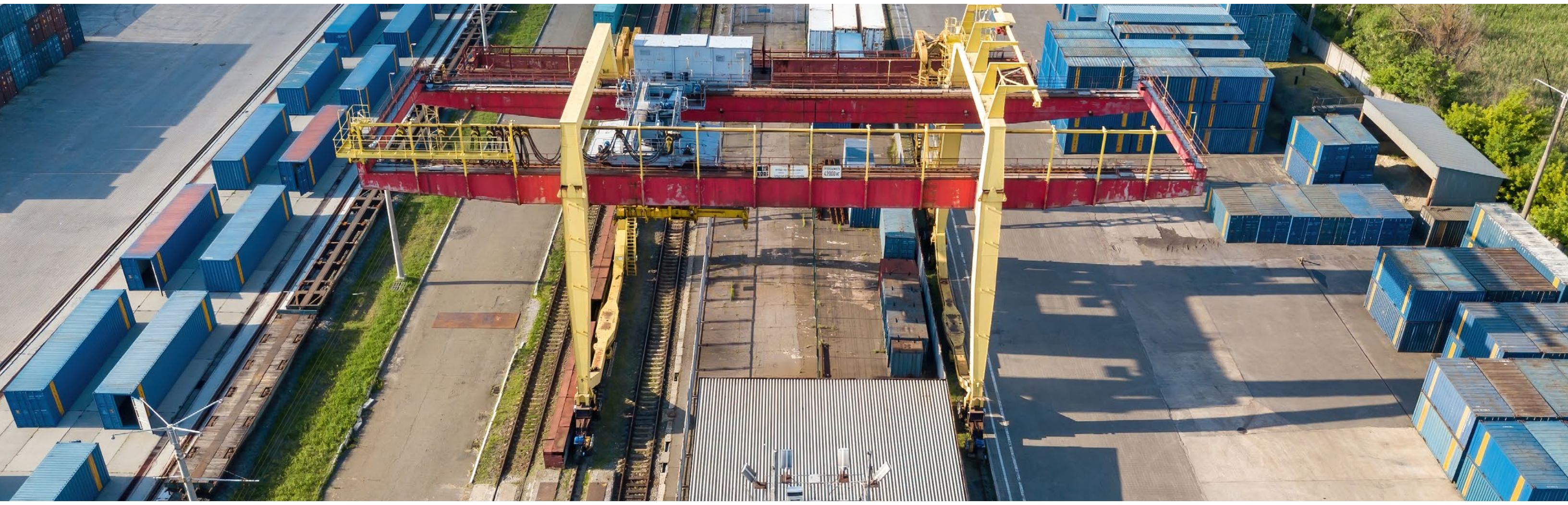
Actions over the near term (initiated before 2030) involve leveraging IRA and BIL incentives to support the deployment of ZEVs in early medium- and heavy-duty markets and expand their market share in passenger (light-duty) vehicles. Billions of USD in transportation tax credits, infrastructure, and supply-chain investments are currently being made throughout the United States through BIL and IRA funds. The Blueprint outlined the critical need to develop energy-refueling infrastructure, particularly critical freight hubs. Since the release of the Blueprint, the U.S. freight corridor strategy was developed and released. This plan outlined the phased approach of critical EV charging and hydrogen fueling networks. Work should continue with utilities, utility regulators, and other grid stakeholders to ensure a balance of needs for electrification. There's a critical need to scale up component manufacturing and fuel production incentivized by IRA tax credits, including biofuels and hydrogen production for legacy vehicles, and domestic tax credits for the manufacture of batteries. The United States will need to expand production of biofuels and hydrogen to further support the harder-to-decarbonize sectors of rail, maritime, and off-road. Engaging in further research, data collection, demonstrations, and outreach for future ZEV deployments, hydrogen fuel-cell technologies, and biofuel production and deployment will be essential for emerging markets. International leadership will continue to play a critical role in building out international infrastructure and standards for aviation, rail, and maritime. These actions will set the foundation for future actions to fully decarbonize the transportation system by 2050.

Midterm actions (beginning before 2035) will need to focus on finalizing and ensuring that BIL and IRA investments are fully leveraged. Transitioning demonstrations to market technologies will be essential during this timeframe. The United States will need to expand ZEV adoption from early market to full-scale production and new market segments. This will include further establishing regional and international corridors and intermodal infrastructure networks for passenger, freight, maritime, off-road, and rail-fueling networks; and scaling and supporting investments in zero- and low-emission vessels and vehicles. Implementing EPA's Multi-Pollutant and Phase 3 Greenhouse Gas Emissions Standards, and National Highway Traffic Safety Administration's Corporate Average Fuel Economy Standards, through model year 2032 will continue the deployment and adoption of ZEVs in the light- and medium-/heavy-duty sectors. Midterm actions may also involve future rulemaking and legislative efforts in these sectors.

Long-term actions (2035 and beyond) will be responsive to market developments and will likely include expanding ZEV and low-emission vessel and vehicle adoption to all market segments, as well as achieving full build-out of corridor energy infrastructure for all modes, both domestically and internationally. Realizing cost reductions in ZEVs to reach parity with ICE vehicles, and supporting sustainable liquid fuel adoption for legacy vehicles, will be essential. Production and bunkering of zero- and low-emission fuels will need to expand and scale for use in the aviation, maritime, and off-road sectors.

## 10.2 An Action Plan for Rail Energy and Emissions Innovation

The action plan for rail proposes actions to nearly eliminate GHG emissions in the U.S. rail sector, in line with the U.S. economy-wide goal of net-zero GHG emissions by 2050. Over the near term and midterm, the plan proposes accelerated adoption of energy-efficiency measures and seeks to leverage opportunities to use available and future low-carbon liquid fuels. The plan also proposes actions and strategies to improve system-wide convenience and efficiency of freight and passenger movement across modes. Long-term solutions leverage technically available options for electrification (i.e., via catenary and discontinuous catenary technologies) and prioritize research and demonstration for emerging zero-emission locomotives and infrastructure, including hydrogen fuel-cell



and battery technologies. In addition, there are several cross-cutting actions across all action plans in support of the Blueprint: develop a framework to collect the data necessary to track progress with the decarbonization objectives; support development of the workforce needed to manufacture and maintain new vehicle technologies and infrastructure; and decarbonize the national electricity grid.

## 10.3 Call to Action

Transforming the rail sector, other transportation modes, and the entire national transportation system over the next three decades will be a complex endeavor, but by taking a comprehensive and coordinated approach, it is a challenge that we can, and must, solve. The strategies presented in these action plans identify unique opportunities, and they will be most effective if decision makers, acting quickly and in concert, continually increase the ambitions of their actions, collaboration, and investments. There is no one technology, policy, or approach that will solve our transportation challenges unilaterally; we need to develop, deploy, and integrate a wide array of technologies and solutions to ensure we achieve our 2030 and 2050 goals.

In addition to leadership at the federal level, reaching these ambitious climate goals will require collaboration with all levels of government, industry, communities, and non-profit organizations. The action plans are intended to send a strong signal to our partners and other stakeholders, to use the documents as guideposts and frameworks to support and complement their own planning and investments, and to coordinate actions in each sector. We will continue to set bold targets for improving our transportation systems and transitioning to ZEVs, vessels, and fuels on a timeline consistent with achieving economy-wide 2030 and 2050 emissions reduction goals. As we decarbonize our transportation system, we can create a more affordable and equitable transportation system that will provide multiple benefits to all Americans for generations to come. It will be important to continually evaluate and update our actions as technology and policy continue to evolve, and to continue strengthening the collaborations between DOE, DOT, EPA, HUD, and all our partners. Together, we must act decisively now to provide better mobility options, reduce inequities, and offer affordable and clean mobility solutions to ensure the health of the planet for future generations. **It is up to all of us to make that vision a reality and move forward with creative and innovative solutions toward a better future for all.**

»

# ACRONYM LIST

AAR ...... Association of American Railroads
ARPA-E ...... Advanced Research Projects Agency – Energy
ATVM ...... Advanced Technology Vehicles Manufacturing Loan Program
BD ...... biodiesel
BETO ...... Bioenergy Technologies Office
BEV ...... battery electric vehicle
BIL ...... Bipartisan Infrastructure Law
BMWED-IBT ...... Brotherhood of Maintenance-of-Way Employes Division of the International Brotherhood of Teamsters
BT23 ...... 2023 Billion Ton Report
Btu ...... British thermal unit
CAAAC ...... Clean Air Act Advisory Committee
CARB ...... California Air Resources Board
CBO ...... Congressional Budget Office
CCS ...... carbon capture and storage
$CH_4$ ...... methane
CHSR ...... California High-Speed Rail
CI ...... carbon intensity
CMAQ ...... Congestion Mitigation and Air Quality Improvement Program
CN ...... Canadian National Railway
$CO_2$ ...... carbon dioxide
$CO_2e$ ...... carbon dioxide equivalent
CoE ...... Center of Excellence
Corridor ID ...... Corridor Identification and Development
CPKC ...... Canadian Pacific Kansas City
CPRG ...... Climate Pollution Reduction Grants
CRISI ...... Consolidated Rail Infrastructure and Safety Improvements
DERA ...... Diesel Emissions Reduction Act
DOE ...... U.S. Department of Energy
DOT ...... U.S. Department of Transportation
EERE ...... Office of Energy Efficiency and Renewable Energy
EMU ...... electric multiple unit
EO ...... Executive Order
EPA ...... U.S. Environmental Protection Agency
EVSE ...... electric vehicle supply equipment
FAF ...... Freight Analysis Framework
FHWA ...... Federal Highway Administration
FOG ...... fats, oils, and greases
FRA ...... Federal Railroad Administration
FSP ...... Federal-State Partnership for Intercity Passenger Rail
FTA ...... Federal Transit Administration
$GH_2$ ...... gaseous hydrogen
GHG ...... Greenhouse gas emissions
GREET ...... Greenhouse gases, Regulated Emissions, and Energy use in Technologies
$H_2$ ...... hydrogen
$H_2ICE$ ...... hydrogen internal combustion engine
HDV ...... heavy-duty vehicle
HFC ...... hydrogen fuel cell
HFTO ...... Hydrogen and Fuel Cell Technologies Office

HSR ..................... high-speed rail

HUD ..................... U.S. Department of Housing and Urban Development

HVDC ..................... high-voltage direct current

IBEW ..................... International Brotherhood of Electrical Workers

ICE ..................... internal combustion engine

IRA ..................... Inflation Reduction Act

kg ..................... kilogram

kWh ..................... kilowatt-hour

lb. ..................... pound

LCA ..................... life cycle assessment

LDV ..................... light-duty vehicle

$LH_2$ ..................... liquid hydrogen

LPO ..................... Loan Programs Office

LRI ..................... Locomotive Replacement Initiative

MARAD ..................... Maritime Administration

MBTA ..................... Massachusetts Bay Transit Authority

MMT ..................... million metric tons

MMT $CO_2e$ ..................... million metric tons of carbon dioxide equivalent

MOU ..................... Memorandum of Understanding

mph ..................... miles per hour

MSTRS ..................... Mobile Source Technical Review Subcommittee

MTA ..................... Metropolitan Transportation Authority

MWh ..................... megawatt-hour

$N_2O$ ..... nitrous oxide
NEC ..... Northeast Corridor
NEI ..... National Emissions Inventory
NOFO ..... notice of funding opportunity
$NO_x$ ..... nitrogen oxides
NS ..... Norfolk Southern
NTD ..... National Transit Database
OCS ..... overhead catenary system
OEM ..... original engine manufacturer
PIDP ..... Port Infrastructure Development Program
PLA ..... project labor agreement
PPP ..... public-private partnership
PM ..... particulate matter
PSR ..... precision scheduled railroading
PURPA ..... Public Utility Regulatory Policies Act
RAISE ..... Rebuilding American Infrastructure with Sustainability and Equity
RCE ..... Railroad Crossing Elimination
RD ..... renewable diesel
RD&D ..... research, development, and demonstration
RGI ..... rail-to-grid integration
ROW ..... right-of-way
RRIF ..... Railroad Rehabilitation and Improvement Financing
SAF ..... sustainable aviation fuel
SCR ..... selective catalytic reduction
SGR ..... state of good repair
SOV ..... single-occupancy vehicle
STBG ..... Surface Transportation Block Grant
TCO ..... total cost of ownership
TIFIA ..... Transportation Infrastructure Finance and Innovation Act
TOD ..... transit-oriented development
TRL ..... technology readiness level
TTC ..... Transportation Technology Center
TWC ..... Transit Workforce Center
U.K. ..... United Kingdom
UP ..... Union Pacific
USD ..... United States dollars
USG ..... United States government
VMT ..... vehicle miles traveled
VTO ..... Vehicle Technologies Office
ZEV ..... zero-emission vehicle

# APPENDIX A: BIOFUELS' ROLE IN DECARBONIZING THE TRANSPORTATION SECTOR

**Context**

Historically, the U.S. transportation sector has overwhelmingly relied on liquid petroleum-based fuels, which supplied over 90% of its energy needs in 2022.[210] The U.S. Transportation Decarbonization Blueprint laid out a bold plan to move the transportation sector to net-zero emissions, using a range of low-GHG fuels, including electrification, hydrogen, and liquid fuels from biomass and other waste carbon resources, such as $CO_2$ and food waste (referred to here collectively as "biofuels"). Biofuels already contribute to on-road light-, medium-, and heavy-duty transportation on the order of billions of gallons, driven by decades of U.S. policy objectives such as energy security, clean air, lead-free octane enhancement of gasoline, climate change mitigation, and rural economic development. The Blueprint identifies aviation as the transportation sector with the greatest long-term opportunity for biofuels, as aviation is limited in low-GHG options. Due to biofuel compatibility with existing fleets and fueling infrastructure, biofuels will play an important role in reducing carbon emissions across all modes during the transition to zero-emission solutions. In particular, biofuels will be important in decarbonizing the legacy fleet in the rail, marine, and off-road sectors due to long equipment lifetime and slow fleet turnover in these modes. The Blueprint also recognizes that biofuels will play a supporting role where electrification and hydrogen may not be as practical. Successfully managing these competing demands for biofuels will be a key challenge going forward. Converting bioenergy from one sector to another does not automatically reduce transportation GHG emissions unless the first sector is reduced or carefully replaced with another energy source.

More biofuels beyond current production are needed. To avoid direct land-use actions such as converting to more agricultural land for producing corn and soybeans currently used for biofuels, a critical near-term action within approximately 10 years for biofuels is to pivot to accessing unused and underused biomass already available, which is estimated at around 350 million dry tons per year, including over 130 million dry tons of agricultural residues, over 170 million dry tons of a variety of wastes, and over 30 million dry tons of forestland resources.[211]

The United States Aviation Climate Action Plan establishes a goal of net-zero emissions from U.S. aviation by 2050. The SAF Grand Challenge establishes a goal of, by 2030, 3 billion gallons of sustainable aviation fuel (SAF) that achieves at least a 50% reduction in emissions on a life cycle basis and 35 billion gallons by 2050.[212] The SAF Grand Challenge Roadmap,[213] which was developed by USG agencies with extensive input from researchers, nongovernmental organizations, and industry, outlines a whole-of-government approach with coordinated policies and activities that should be undertaken by federal agencies to achieve both the 2030 and 2050 goals. In the *SAF Grand Challenge Roadmap*, the vast majority of the policies and activities focus on the needs for innovation in feedstock and conversion technologies that are largely agnostic to fuel type. As discussed in the action plans, decarbonizing maritime freight may require large volumes of methanol, decarbonizing noncommercial maritime vessels may require significant volumes of green gasoline, and decarbonizing the off-road, rail, and long-haul heavy-duty modes may require large volumes of biomass-based diesel. The Blueprint recognizes that biofuels will play a leading role for aviation decarbonization while playing a supporting role for decarbonizing other transportation sectors.

In addition to the Blueprint, the U.S. goals and strategies for biofuels are also driven by the National Biotechnology and Biomanufacturing Initiative and coordinated through the National Bioeconomy Board. This appendix seeks to complement modal plans by summarizing USG goals and strategies for biofuels that are not specific to individual modes of transportation and thus not fully integrated within specific modal plans.

**Biofuels Background**

The United States is the world's largest biofuels producer, producing 15 billion gallons of ethanol and over 3 billion gallons of biomass-based diesel in 2022.[214] These fuels are typically blended into gasoline and diesel, respectively, for use in on-road transportation. Most U.S. ethanol is produced from fermentation of cornstarch. U.S. biomass-based diesel is currently produced via either hydroprocessing, co-processing, or transesterification and uses lipid feedstocks that include oilseeds (e.g., soy, canola) and waste fats, oils, and greases (FOGs), such as used cooking oil. While the United States has these domestic supplies of biofuels, the supply is far from sufficient to satisfy the energy needs of the entire U.S. transportation sector.

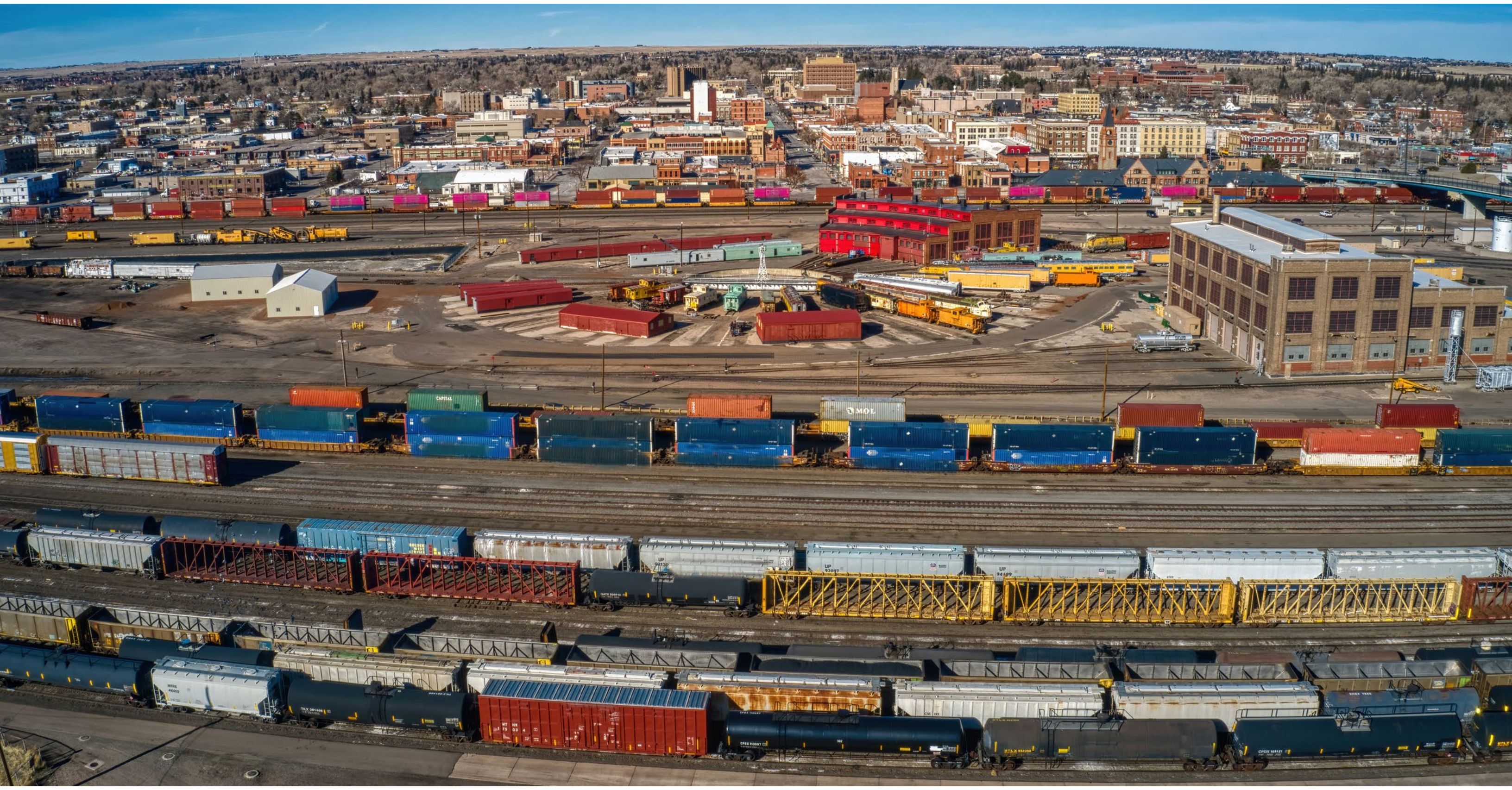
Maximizing the impact of biofuels in support of the Blueprint will require expanding biofuels production, primarily through new feedstocks and production pathways. Government support will continue to play an important role in developing technologies, building supply chains, and scaling up biofuels production to meet the need for low-carbon liquid fuels. Policy and regulation at the federal and state levels have played and will continue to play a critical role for biofuels production in the United States to drive down CI and expand production.

**Domestic Resource Potential for Biofuel Production**

Currently, most biofuels in the United States are produced from corn and soybean planted on agricultural land. It is important for the U.S. agricultural system to prioritize its most productive land to produce food, feed, and fiber. Therefore, there are limits to the amount of agricultural land that can be used for biofuel production to meet the energy demands of our transportation sector. While productivity improvements can increase the amount of biofuel feedstock produced from the same acreage, these gains are modest in comparison to the needs for biofuels expansion. USDA projects 2% annual yield improvements for corn and 0.5% yield improvements for soy over the next 10 years.[215] The deployment of intermediate oilseeds that are planted and harvested in between these cash crop rotations could also sustainably expand lipid feedstock supply that can be converted using commercially ready technologies to increase production of SAF and biomass-based diesel with little impact on land use.[216] However, in order to support decarbonization, domestic biofuels production must expand primarily through the use of new feedstocks resources that are not grown on prime agricultural land.

The *2023 Billion-Ton Report* (BT23) estimates the United States has the capacity to sustainably and economically produce 1.3 to 1.5 billion tons of biomass and organic wastes per year in the future, over triple the amount the current U.S. bioeconomy utilizes today.[217] These resources include:

- Agricultural residues (e.g., corn stover, wheat straw) from the production of food, grain, and fiber
- Wastes, including animal manure; wastewater sludge; inedible FOGs; sorted municipal solid waste including unrecyclable paper/cardboard waste, yard waste, and food waste; and landfill gas



- Forest thinnings from small-diameter trees that need removal to increase forest health and reduce wildfire potential, and logging and mill processing residues
- Purpose-grown energy crops (e.g., perennial grasses, fast-growing trees) that can be grown on less productive land with improved environmental performance and lower CI than traditional agricultural production.

Because biomass production potential is contingent upon market pull, BT23 presents production capacity by market scenario. One scenario presented in BT23 is the "near-term scenario," which illustrates resources that exist today[x] (and in 2030). This includes 350 million tons per year of unused biomass (including ~250 million tons per year of cellulosic biomass) in addition to the ~340 million tons of biomass currently used for energy and coproducts (Figure 34). The mature-market scenarios, adding ~440–800 million tons more biomass, include energy crops, which will not be fully deployed by the 2030 SAF target. However, if the SAF Grand Challenge 2030 target of 3 billion gallons per year was met entirely through biofuels, that could require 50–60 million tons of biomass per year,[y] which is merely ~15% of the near-term scenario untapped production capacity (see BT23 Figure ES-1 and Table ES-2).

### USG Goals and Strategies for Biofuels

The U.S. Transportation Decarbonization Blueprint prescribed five guiding principles to guide future policymaking and research, development, demonstration, and deployment in the public and private sectors, which

x Near-term presents resources that are annually available (within specified environmental constraints, at specified prices, and available for collection).

y At an assumed average conversion rate of 55 gallons of biofuels per ton.

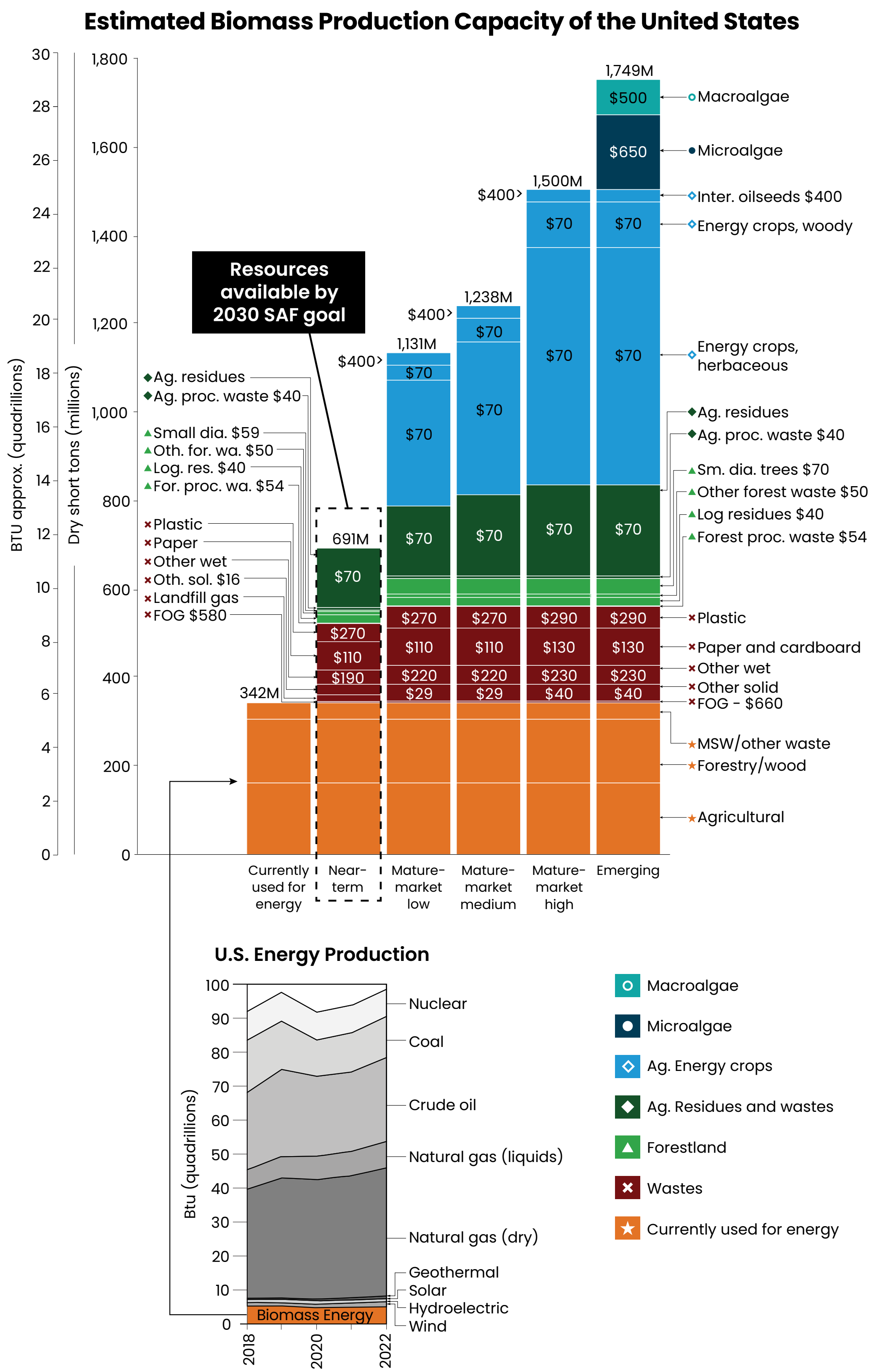



*Figure 34. Estimated biomass production capacity of the United States. The near-term scenario is highlighted, which identifies production capacity in 2030, including 235 million tons per year of unused cellulosic biomass resources. Source: USDOE 2023 Figure ES-1*

are exemplified by the USG's coordinated approach and leadership on biofuels:

- Implement bold actions to achieve measurable results.
- Embrace creative solutions across the entire transportation system.
- Ensure safety, equity, and access.
- Increase collaboration.
- Establish U.S. leadership.

The USG has a long history of biofuels coordination since the Biomass Research and Development Act of 2000. Since then, the Biomass R&D Board has coordinated biofuels-related activities to advance a range of policy objectives, including climate change, energy security, domestic manufacturing, and competitiveness. In recent years, these efforts have been driven by the National Biotechnology and Biomanufacturing Initiative and the SAF Grand Challenge with the mutual objectives of increasing domestic production of biofuels and improving the CI of biofuels production.

Federal government agencies developed a series of Bold Goals for U.S. Biotechnology and Biomanufacturing R&D in March 2023,[218] which include several goals that align with the U.S. Transportation Decarbonization Blueprint. These goals focus on expanding the availability and sustainability of feedstocks for the production of biofuels and increasing the production of SAF and biofuels for other hard-to-decarbonize modes of transportation.

### Strategies to Achieve Near-Term Biofuel Goals

BT23 estimates there are 350 million dry short tons per year of biomass above current uses that are near-term opportunities that could be accessible for biofuels in the next 5–10 years. Some of these resources, such as wastes, are already collected but then landfilled. Others, such as agricultural

residues and timberland resources, exist in fields and forests but must be collected for use. Most of this near-term biomass is lignocellulosic. Technologies to produce liquid fuels from lignocellulosic biomass have not been fully de-risked. Given the significant lead time required for biofuels production infrastructure to be built, the path to meeting near-term goals focuses on actions to scale the harvesting/collection and scaling of these resources and the production facilities that can turn them into biofuels as quickly as practicable. These actions include:

- Demonstrate new biofuel pathways that can produce biofuels from additional feedstocks beyond lipids and starch.
- Build and support stakeholder coalitions through outreach, extension, and education to set the stage for biofuel feedstock and biofuel supply chains to develop and sustain themselves and replicate with continuous improvement.
- Increase deployment of alternative lipid feedstocks, including intermediate oilseeds that can be readily converted to SAF and biomass-based diesel through commercially available conversion technologies.[z]

z The BT23 near-term scenario does not include intermediate oilseeds because these feedstocks are not currently widely available. However, this is a resource that has been prioritized under the SAF Grand Challenge as a near-term opportunity due to significant increase in demand for lipid feedstocks for the production of SAF and biomass-based diesel.

Bold Goals for U.S. Biotechnology and Biomanufacturing R&D:

| | |
|---|---|
| GOAL **1.1** | **Expand Feedstock Availability – In 20 years, collect and process 1.2 billion metric tons of conversion-ready, purpose-grown plants and waste-derived feedstocks and utilize >60 million metric tons of exhaust gas $CO_2$ suitable for conversion to fuels and products, while minimizing emissions, water use, habitat conversion, and other sustainability challenges.** |
| GOAL **1.2** | **Produce SAF – In 7 years, produce 3 billion gallons of SAF with at least 50% (stretch 70%) reduction in GHG life cycle emissions relative to conventional aviation fuels, with production rising to 35 billion gallons in 2050.** |
| GOAL **1.3** | **Develop Other Strategic Fuels – In 20 years, develop technologies to replace 50% (>15 billion gallons) of maritime fuel, off-road vehicle fuel, and rail fuel with low net GHG emission fuels.** |
| GOAL **3.1** | **Develop Measurement Tools for Robust Feedstock Production Systems – In 5 years, develop new tools for measurement of carbon and nutrient fluxes in agricultural and bioeconomy feedstock systems that contribute to a national framework.** |
| GOAL **3.2** | **Engineer Better Feedstock Plants – In 5 years, engineer plants and manipulate plant microbiomes to produce drought-tolerant feedstocks capable of growing on underutilized land with >20% improvement in nitrogen and phosphorus use efficiency.** |

- Improve the CI of biofuels production using commercially available feedstocks and infrastructure.
- Develop improved environmental models and data for biofuels to support optimization of existing policies and implementation of new policies that could be enacted.
- Inform biofuels policy development with analysis of gaps and impacts of policies under consideration.
- Stakeholder outreach and engagement on sustainability to exchange data and information about best practices to reduce life cycle GHG emissions from agricultural

and forest-derived feedstocks and optimize other environmental and social impacts.

- Enable use of drop-in unblended biofuels and biofuel blends up to 100% to simplify blending requirements, reduce the cost of logistics, and facilitate supply.

**Strategies to Achieve Long-Term Biofuel Goals**

The path to meeting long-term biofuel and decarbonization goals requires a continuing focus on innovation, including research, development, and demonstration (RD&D) of new feedstock and conversion technologies, increasing production capacity with continued progress in cost reductions and CI. This effort occurs simultaneously with the near-term strategies above such that these innovations can be demonstrated and scaled by 2050. Technologies in this portfolio are expected to result in a dramatic build-out and expansion of alcohol, waste-based, lignocellulosic, and waste and captured carbon gas pathways.

- Conduct RD&D on scaling and sustainability of biomass, waste, and residue feedstocks to enable innovations in technologies and strategies that increase the availability of purpose-grown energy crops, wastes, and agricultural and forestry residues at reduced CI and cost. This includes addressing the social, environmental, and economic sustainability aspects of feedstock supply chains.
- Conduct RD&D on feedstock logistics and handling reliability to increase efficiencies and decrease cost and CI of supply logistics from the producer's field to the conversion facility door.
- De-risk scale-up through R&D and integrated piloting of critical pathways by 2030 to accelerate fuel conversion technology scale-up and improve financeability of critical conversion pathways that use the full potential of an expanded feedstock supply.
- Model and demonstrate sustainable regional supply chains for critical pathways by 2035 to promote commercialization of biofuel supply chains through process validation and risk reduction via access to critical data and tools that empower rapid, informed decision-making when evaluating biofuel supply chain options.
- Build and support regional stakeholder coalitions through outreach, extension, and education to continue to expand a biofuels industry that improves environmental and economic performance while supporting job creation and social equity in multiple regions of the country.
- Continue to invest in industry deployment to help overcome barriers to project financing through creative financing, government loans and loan guarantees, and outreach.
- Continue to inform biofuel policy development to enable aligned policy incentives that will support long-term biofuel deployment.

**Conclusion**

Biofuels will play an important role in reducing carbon emissions across all modes of transportation, whether as a long-term decarbonization strategy or as a transition to zero-emission solutions. USG agencies have identified goals and strategies to improve CI and sustainability of biofuels and to expand biofuels production—particularly through developing supply chains and technology necessary to produce biofuels from purpose-grown energy crops, wastes, and agricultural and forest residues. While USG has placed a priority on producing biofuels for aviation due to the lack of alternative low-GHG options, it will be important to periodically assess fleet turnover and zero-emission vehicle adoption rates across various modes of transportation to inform the optimal allocation of biofuels across these modes to maximize the GHG benefits of biofuel use.

# APPENDIX B: RAILROAD EMISSIONS INFORMATION

**Table 11: 2020 Freight Locomotive Distribution by Tier for Class I, II, and III Railroads**

| | Class I line-haul | Class I yard | Class II/III |
|---|---|---|---|
| **Class I line-haul tier level** | **Count** | **Count** | **Count** |
| Not Classified/pre-tier 0 | 333 | 912 | 1,359 |
| Tier 0 (1973–2001) | 887 | 673 | 1,664 |
| Tier 0+ (Tier 0 rebuilds) | 2,300 | 1,182 | - |
| Tier 1 (2002–2004) | 119 | - | 31 |
| Tier 1+ (Tier 1 rebuilds) | 4,288 | 26 | - |
| Tier 2 (2005–2011) | 770 | 7 | 169 |
| Tier 2+ (Tier 2 rebuilds) | 3,792 | - | - |
| Tier 3 (2012–2014) | 2,422 | 11 | 160 |
| Tier 4 (2015 and later) | 1,181 | 23 | 64 |
| Tier 4C (Tier 3 specs, built after 2014) | 695 | - | - |
| **Total** | **16,787** | **2,834** | **3,447** |

Note that the totals are different than those presented in section Rail Market Segments and Emissions because 2022 data on fleet distribution are not yet available.

**Table 12: Estimated Annual Tailpipe (Scope 1) Emissions from Freight and Passenger Rail Operations in 2019 (Metric Tons/Year)**

| | Class I | | Class II/III | Passenger | | Total rail |
|---|---|---|---|---|---|---|
| | Line-haul | Yard | Line-haul | Commuter | Amtrak | |
| Methane ($CH_4$) | 2,233 | 146 | 121 | 70 | 41 | 2,610 |
| Carbon dioxide ($CO_2$) | 28,330,976 | 1,855,479 | 1,533,987 | 881,255 | 513,351 | 33,115,048 |
| Nitrous oxide ($N_2O$) | 726 | 47 | 39 | 23 | 14 | 848 |
| Carbon monoxide (CO) | 74,314 | 5,085 | 3,521 | 2,312 | 1,346 | 86,577 |
| Ammonia ($NH_3$) | 232 | 15 | 13 | 7 | 5 | 271 |
| $NO_x$ | 336,290 | 36,531 | 27,033 | 11,276 | 7,850 | 418,981 |
| $PM_{10}$ | 8,491 | 959 | 815 | 302 | 265 | 10,832 |
| $PM_{2.5}$ | 8,236 | 930 | 791 | 293 | 257 | 10,506 |
| Sulfur dioxide ($SO_2$) | 262 | 17 | 15 | 8 | 5 | 307 |
| Volatile Organic Compounds | 13,550 | 2,372 | 1,288 | 480 | 422 | 18,112 |

Notes: GHG emissions are in **bold**. The 2020 NEI[219] reports short tons, which we have converted to metric tons to be consistent with international reporting. According to AAR, short-line and regional railroads (Class II/III) almost universally operate with dual-service power and thus cannot be subdivided into line-haul and rail yard operations.

# APPENDIX C: RAIL YARDS WITH HIGH POTENTIAL PUBLIC HEALTH BENEFITS FROM A TRANSITION TOWARD ZERO-EMISSION EQUIPMENT

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14415911 | EAST THOMAS | AL | Jefferson | 1073001200 | 749 | 1 | 0.69 | 0.23 | 0.92 | 0.92 | 0.77 | 0.41 | 24.56 | 0.98 | 4.93 |
| 14418311 | NORRIS | AL | Jefferson | 1073012602 | 378 | 1 | 0.47 | 0.76 | 0.86 | 0.86 | 0.79 | 0.39 | 21.84 | 0.86 | 5.00 |
| 14420711 | MOBILE | AL | Mobile | 1097001200 | 154 | 1 | 0.47 | 0.42 | 0.52 | 0.52 | 0.56 | 0.60 | 23.13 | 0.93 | 4.01 |
| 14422411 | THEODORE | AL | Mobile | 1097007102 | 243 | 0 | 0.40 | 0.94 | 0.29 | 0.29 | 0.66 | 0.55 | 19.93 | 0.67 | 3.80 |
| 14422911 | CHESTER | AL | Montgom-ery | 1101000300 | 119 | 1 | 0.31 | 0.94 | 0.29 | 0.29 | 0.97 | 0.66 | 22.42 | 0.90 | 4.36 |
| 14423511 | SHEFFIELD | AL | Colbert | 1033020706 | 191 | 0 | 0.07 | 0.48 | 0.99 | 0.99 | 0.45 | 0.92 | 15.59 | 0.22 | 4.12 |
| 14423611 | CALERA | AL | Shelby | 1117030504 | 333 | 0 | 0.31 | 0.94 | 0.29 | 0.29 | 0.22 | 0.06 | 17.49 | 0.38 | 2.51 |
| 14429611 | GADSDEN | AL | Etowah | 1055000600 | 1965 | 0 | 0.31 | 0.20 | 0.35 | 0.35 | 0.02 | 0.56 | 19.25 | 0.60 | 2.40 |
| 14437311 | BRIDGEPORT | AL | Jackson | 1071950200 | 91 | 0 | 0.24 | 0.94 | 0.29 | 0.29 | 0.93 | 0.36 | 17.19 | 0.36 | 3.41 |
| 14442111 | BESSEMER | AL | Jefferson | 1073010302 | 1932 | 1 | 0.53 | 0.94 | 0.29 | 0.29 | 0.88 | 0.64 | 22.40 | 0.90 | 4.46 |
| 14450511 | BIRMINGHAM | AL | Jefferson | 1073002401 | 1994 | 1 | 0.76 | 0.94 | 0.29 | 0.29 | 0.58 | 0.56 | 22.28 | 0.89 | 4.31 |
| 14459011 | BOYLES | AL | Jefferson | 1073005500 | 577 | 1 | 0.40 | 0.35 | 0.93 | 0.93 | 0.99 | 0.64 | 24.67 | 0.98 | 5.21 |
| 18306711 | SELMA | AL | Dallas | 1047956500 | 1040 | 1 | 0.59 | 0.71 | 0.21 | 0.21 | 1.00 | 0.66 | 22.73 | 0.91 | 4.30 |
| 14434611 | PINE BLUFF | AR | Jefferson | 5069002500 | 9 | 0 | 0.07 | 0.41 | 0.96 | 0.96 | 0.04 | 0.45 | 18.22 | 0.47 | 3.36 |
| 14435311 | TEXARKANA | AR | Miller | 5091020400 | 1165 | 1 | 0.53 | 0.55 | 0.60 | 0.60 | 0.58 | 0.39 | 20.69 | 0.74 | 4.00 |
| 14436511 | BIDDLE YARD | AR | Pulaski | 5119000500 | 1215 | 1 | 0.82 | 0.29 | 0.42 | 0.42 | 0.97 | 0.55 | 21.36 | 0.80 | 4.27 |
| 14437411 | NORTH LITTLE ROCK | AR | Pulaski | 5119002800 | 476 | 1 | 0.59 | 0.62 | 0.99 | 0.99 | 0.02 | 0.66 | 22.56 | 0.91 | 4.78 |
| 15527111 | ASHDOWN | AR | Little River | 5081030101 | 33 | 0 | 0.31 | 0.72 | 0.22 | 0.22 | 0.85 | 0.28 | 17.61 | 0.40 | 2.99 |
| 17862011 | CAMDEN | AR | Ouachita | 5103950600 | 292 | 1 | 0.40 | 0.48 | 0.98 | 0.98 | 0.03 | 0.58 | 21.22 | 0.79 | 4.24 |
| 17866411 | JONESBORO | AR | Craighead | 5031000101 | 3204 | 0 | 0.73 | 0.55 | 0.60 | 0.60 | 0.91 | 0.39 | 18.16 | 0.46 | 4.24 |
| 17868111 | MALVERN | AR | Hot Spring | 5059020200 | 470 | 1 | 0.47 | 0.55 | 0.60 | 0.60 | 0.99 | 0.45 | 21.99 | 0.87 | 4.53 |
| 17868311 | MCGEHEE | AR | Desha | 5041950400 | 38 | 0 | 0.31 | 0.29 | 0.42 | 0.42 | 0.97 | 0.55 | 17.70 | 0.40 | 3.37 |
| 17868911 | NEWPORT | AR | Jackson | 5067480200 | 145 | 0 | 0.18 | 0.29 | 0.42 | 0.42 | 0.01 | 0.41 | 18.41 | 0.50 | 2.22 |
| 17871111 | RUSSELLVILLE | AR | Pope | 5115951400 | 627 | 1 | 0.69 | 0.55 | 0.60 | 0.60 | 0.10 | 0.45 | 19.27 | 0.60 | 3.60 |
| 17872911 | STUTTGART | AR | Arkansas | 5001480300 | 154 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.94 | 0.55 | 17.04 | 0.35 | 3.03 |
| 17873911 | VAN BUREN | AR | Crawford | 5033020501 | 282 | 1 | 0.47 | 0.29 | 0.42 | 0.42 | 0.93 | 0.28 | 20.52 | 0.73 | 3.53 |
| 17875211 | WYNNE | AR | Cross | 5037950500 | 676 | 1 | 0.40 | 0.29 | 0.42 | 0.42 | 0.91 | 0.48 | 21.28 | 0.80 | 3.71 |
| 18338311 | PINE BLUFF (IPC) | AR | Jefferson | 5069002500 | 9 | 0 | 0.18 | 0.29 | 0.42 | 0.42 | 0.04 | 0.45 | 18.22 | 0.47 | 2.26 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19467511 | ALMA | AR | Crawford | 5033020602 | 371 | 0 | 0.40 | 0.29 | 0.42 | 0.42 | 0.58 | 0.89 | 15.90 | 0.24 | 3.24 |
| 19468411 | GRADY | AR | Jefferson | 5069002500 | 9 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.04 | 0.45 | 18.22 | 0.47 | 2.15 |
| 19468911 | JAX | AR | Pulaski | 5119003608 | 2588 | 0 | 0.40 | 0.29 | 0.42 | 0.42 | 0.69 | 0.20 | 18.72 | 0.54 | 2.97 |
| 14427511 | PHOENIX - MOBEST | AZ | Maricopa | 4013116800 | 1278 | 1 | 0.94 | 0.35 | 0.92 | 0.92 | 0.52 | 0.20 | 22.43 | 0.90 | 4.76 |
| 14429711 | WINSLOW | AZ | Navajo | 4017960600 | 149 | 1 | 0.59 | 0.35 | 0.48 | 0.48 | 0.69 | 0.58 | 19.58 | 0.64 | 3.80 |
| 14432311 | CASA GRANDE | AZ | Pinal | 4021001500 | 281 | 1 | 0.53 | 0.55 | 0.60 | 0.60 | 0.77 | 0.57 | 20.03 | 0.67 | 4.31 |
| 14477311 | PHOENIX | AZ | Maricopa | 4013114100 | 6533 | 0 | 0.98 | 0.80 | 0.80 | 0.80 | 0.05 | 0.72 | 18.53 | 0.52 | 4.66 |
| 17862111 | CAMPO | AZ | Maricopa | 4013114600 | 1993 | 1 | 0.88 | 0.55 | 0.60 | 0.60 | 0.35 | 0.36 | 23.50 | 0.95 | 4.30 |
| 17873211 | TUCSON | AZ | Pima | 4019002000 | 3516 | 1 | 0.95 | 0.44 | 0.97 | 0.97 | 0.48 | 0.20 | 19.89 | 0.66 | 4.68 |
| 17875311 | YUMA | AZ | Yuma | 4027000100 | 1380 | 1 | 0.89 | 0.55 | 0.60 | 0.60 | 0.48 | 0.28 | 20.18 | 0.69 | 4.10 |
| 18700311 | BUCKEYE (UP) | AZ | Maricopa | 4013050702 | 2101 | 1 | 0.64 | 0.29 | 0.42 | 0.42 | 0.40 | 0.43 | 20.35 | 0.71 | 3.31 |
| 19465511 | CHANDLER | AZ | Maricopa | 4013523102 | 5728 | 0 | 0.89 | 0.29 | 0.42 | 0.42 | 0.11 | 0.39 | 19.16 | 0.60 | 3.11 |
| 19466911 | PICACHO | AZ | Pinal | 4021000802 | 6 | 0 | 0.18 | 0.29 | 0.42 | 0.42 | 0.45 | 0.02 | 15.82 | 0.23 | 2.01 |
| 19674311 | ALDONA | AZ | Pima | 4019980001 | 1 | 0 | 0.31 | 0.69 | 0.73 | 0.73 | 0.07 | 0.89 | 14.59 | 0.13 | 3.56 |
| 19674411 | TOLLESON | AZ | Maricopa | 4013083000 | 1527 | 1 | 0.80 | 0.55 | 0.60 | 0.60 | 0.31 | 0.25 | 21.15 | 0.78 | 3.90 |
| 14440911 | RICHMOND | CA | Contra Costa | 6013378000 | 543 | 0 | 0.89 | 0.64 | 0.68 | 0.68 | 0.27 | 0.74 | 19.49 | 0.62 | 4.53 |
| 14441611 | CALWA | CA | Fresno | 6019001201 | 2669 | 1 | 0.69 | 0.81 | 0.81 | 0.81 | 0.33 | 0.36 | 24.86 | 0.98 | 4.79 |
| 14442211 | FRESNO | CA | Fresno | 6019003805 | 8434 | 1 | 0.89 | 0.21 | 0.90 | 0.90 | 0.22 | 0.36 | 22.10 | 0.87 | 4.36 |
| 14443811 | EL CENTRO | CA | Imperial | 6025011400 | 2905 | 1 | 0.91 | 0.80 | 0.80 | 0.80 | 0.85 | 0.48 | 24.91 | 0.98 | 5.61 |
| 14447911 | CITY OF INDUSTRY | CA | Los Angeles | 6037980035 | 101 | 1 | 0.95 | 0.84 | 0.84 | 0.84 | 0.16 | 0.81 | 24.20 | 0.97 | 5.40 |
| 14455311 | DAVIS | CA | Placer | 6061020901 | 3957 | 1 | 0.82 | 0.44 | 0.97 | 0.97 | 0.45 | 0.36 | 22.07 | 0.87 | 4.89 |
| 14456011 | PORTOLA | CA | Plumas | 6063000300 | 7 | 0 | 0.31 | 0.29 | 0.42 | 0.42 | 0.53 | 0.11 | 16.55 | 0.30 | 2.39 |
| 14457211 | OAKLAND | CA | Alameda | 6001981900 | 27 | 0 | 0.53 | 0.29 | 0.42 | 0.42 | NA | NA | 14.09 | 0.09 | NA |
| 14460411 | POLK | CA | Sacra-mento | 6067009201 | 313 | 0 | 0.78 | 0.29 | 0.42 | 0.42 | 0.56 | 0.98 | 21.52 | 0.82 | 4.27 |
| 14462011 | BARSTOW | CA | San Bernardino | 6071009400 | 913 | 1 | 0.59 | 0.65 | 1.00 | 1.00 | 0.79 | 0.62 | 24.48 | 0.97 | 5.62 |
| 14467511 | MORMON | CA | San Joaquin | 6077001900 | 5211 | 1 | 0.97 | 0.47 | 0.98 | 0.98 | 0.65 | 0.47 | 22.57 | 0.91 | 5.41 |
| 14468211 | STOCKTON YARD | CA | San Joaquin | 6077002201 | 3673 | 1 | 0.89 | 0.36 | 0.93 | 0.93 | 0.69 | 0.58 | 22.61 | 0.91 | 5.30 |
| 14469611 | TRACY | CA | San Joaquin | 6077005405 | 7126 | 0 | 0.91 | 0.55 | 0.60 | 0.60 | 0.13 | 0.02 | 17.70 | 0.41 | 3.22 |
| 14471611 | BENECIA | CA | Solano | 6095252102 | 132 | 0 | 0.31 | 0.55 | 0.60 | 0.60 | 0.18 | 0.98 | 17.67 | 0.40 | 3.64 |
| 14474111 | OXNARD | CA | Ventura | 6111009100 | 4325 | 1 | 0.94 | 0.55 | 0.60 | 0.60 | 0.66 | 0.46 | 24.94 | 0.98 | 4.81 |
| 14477411 | LOS ANGELES EAST YARD | CA | Los Angeles | 6037532302 | 3481 | 1 | 0.98 | 0.69 | 0.73 | 0.73 | 0.22 | 0.98 | 24.83 | 0.98 | 5.31 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14477711 | SAN BERNARDINO | CA | San Bernardino | 6071004902 | 2962 | 1 | 0.96 | 0.39 | 0.95 | 0.95 | 0.43 | 0.45 | 24.24 | 0.97 | 5.11 |
| 14477911 | WEST COLTON | CA | San Bernardino | 6071004004 | 672 | 1 | 0.84 | 0.88 | 0.87 | 0.87 | 0.18 | 0.02 | 22.23 | 0.88 | 4.55 |
| 17860411 | ANAHEIM | CA | Orange | 6059087105 | 7106 | 1 | 0.97 | 0.29 | 0.42 | 0.42 | 0.29 | 0.81 | 23.89 | 0.96 | 4.15 |
| 17860711 | ARLINGTON | CA | Riverside | 6065030900 | 1356 | 0 | 0.59 | 0.55 | 0.60 | 0.60 | 0.11 | 0.77 | 20.68 | 0.74 | 3.97 |
| 17863711 | EAST OAKLAND | CA | Alameda | 6001406000 | 5126 | 0 | 0.99 | 0.29 | 0.42 | 0.42 | 0.38 | 0.92 | 21.49 | 0.81 | 4.23 |
| 17865011 | GEMCO | CA | Los Angeles | 6037120300 | 8307 | 1 | 0.97 | 0.55 | 0.60 | 0.60 | 0.11 | 0.73 | 22.49 | 0.90 | 4.47 |
| 17865411 | GUADALUPE | CA | Santa Barbara | 6083002504 | 4608 | 0 | 0.31 | 0.29 | 0.42 | 0.42 | 0.25 | 0.17 | 17.32 | 0.37 | 2.24 |
| 17866511 | KAISER | CA | San Bernardino | 6071002204 | 824 | 1 | 0.24 | 0.55 | 0.60 | 0.60 | 0.11 | 0.92 | 23.13 | 0.93 | 3.96 |
| 17867811 | LONG BEACH (ITCF) | CA | Los Angeles | 6037980014 | 52 | 0 | 0.80 | 0.84 | 0.84 | 0.84 | 0.77 | 0.70 | 15.56 | 0.22 | 5.02 |
| 17868011 | LOS NIETOS | CA | Los Angeles | 6037502700 | 2862 | 0 | 0.95 | 0.69 | 0.73 | 0.73 | 0.16 | 0.72 | 21.60 | 0.82 | 4.80 |
| 17869911 | OZOL | CA | Contra Costa | 6013316000 | 1426 | 0 | 0.47 | 0.55 | 0.60 | 0.60 | 0.27 | 0.28 | 20.73 | 0.75 | 3.52 |
| 17870511 | REDDING | CA | Shasta | 6089010602 | 2032 | 0 | 0.76 | 0.55 | 0.60 | 0.60 | 0.38 | 0.98 | 15.82 | 0.23 | 4.11 |
| 17870811 | ROGERS | CA | Stanislaus | 6099002505 | 10049 | 0 | 0.88 | 0.29 | 0.42 | 0.42 | 0.09 | 0.11 | 20.40 | 0.72 | 2.92 |
| 17872411 | SOUTH SAN FRANCISCO | CA | San Mateo | 6081602300 | 986 | 0 | 0.76 | 0.29 | 0.42 | 0.42 | 0.17 | 0.70 | 17.98 | 0.44 | 3.19 |
| 17873311 | TULARE | CA | Tulare | 6107003001 | 8259 | 0 | 0.89 | 0.29 | 0.42 | 0.42 | 0.63 | 0.51 | 21.76 | 0.86 | 4.02 |
| 17874211 | WARM SPRINGS | CA | Alameda | 6001441525 | 905 | 0 | 0.40 | 0.99 | 0.89 | 0.89 | 0.01 | 0.68 | 16.14 | 0.26 | 4.12 |
| 17874411 | WATSONVILLE JCT | CA | Monterey | 6053010102 | 271 | 0 | 0.69 | 0.55 | 0.60 | 0.60 | 0.18 | 0.77 | 13.85 | 0.08 | 3.48 |
| 17875411 | LATC | CA | Los Angeles | 6037199700 | 9086 | 1 | 0.99 | 0.88 | 0.87 | 0.87 | 0.16 | 0.81 | 25.35 | 0.99 | 5.56 |
| 17875511 | LOS ANGELES J YARD | CA | Los Angeles | 6037206051 | 1790 | 0 | 0.99 | 0.55 | 0.60 | 0.60 | 0.04 | 0.68 | 20.90 | 0.76 | 4.24 |
| 17875611 | MIRA LOMA | CA | Riverside | 6065040503 | 2545 | 1 | 0.53 | 0.29 | 0.42 | 0.42 | 0.87 | 0.89 | 25.50 | 0.99 | 4.41 |
| 17875711 | VALLA | CA | Los Angeles | 6037502700 | 2862 | 0 | 0.92 | 0.29 | 0.42 | 0.42 | 0.16 | 0.72 | 21.60 | 0.82 | 3.75 |
| 18312511 | COMMERCE | CA | Los Angeles | 6037532303 | 1495 | 1 | 0.84 | 0.37 | 0.94 | 0.94 | 0.27 | 0.92 | 24.60 | 0.98 | 5.25 |
| 18313211 | SAN DIEGO | CA | San Diego | 6073005103 | 4163 | 0 | 0.95 | 0.21 | 0.91 | 0.91 | 0.21 | 0.15 | 19.86 | 0.66 | 4.00 |
| 18338411 | BAKERSFIELD (UP) | CA | Kern | 6029001202 | 10587 | 1 | 0.91 | 0.55 | 0.60 | 0.60 | 0.43 | 0.62 | 24.09 | 0.97 | 4.69 |
| 19465111 | CARMENITA | CA | Los Angeles | 6037554511 | 4387 | 0 | 0.82 | 0.55 | 0.60 | 0.60 | 0.10 | 0.68 | 20.47 | 0.73 | 4.09 |
| 19465211 | BERTH 200 | CA | Los Angeles | 6037980014 | 52 | 0 | 0.69 | 0.55 | 0.60 | 0.60 | 0.77 | 0.70 | 15.56 | 0.22 | 4.15 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19469311 | EMERYVILLE | CA | Alameda | 6001425103 | 8596 | 0 | 0.94 | 0.29 | 0.42 | 0.42 | 0.04 | 0.74 | 16.04 | 0.25 | 3.10 |
| 19469911 | PORT CHICAGO | CA | Contra Costa | 6013315000 | 181 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.10 | 0.83 | 18.27 | 0.48 | 3.24 |
| 19674611 | DOLORES | CA | Los Angeles | 6037543306 | 4929 | 0 | 0.80 | 0.80 | 0.80 | 0.80 | 0.13 | 0.72 | 23.03 | 0.93 | 4.97 |
| 19674711 | FOURTH STREET YARD | CA | Los Angeles | 6037206050 | 3360 | 1 | 0.99 | 0.29 | 0.42 | 0.42 | 0.97 | 0.06 | 25.39 | 0.99 | 4.13 |
| 19674811 | LATHROP | CA | San Joaquin | 6077005119 | 681 | 0 | 0.31 | 0.55 | 0.60 | 0.60 | 0.08 | 0.77 | 19.22 | 0.60 | 3.52 |
| 19674911 | MONTCLAIR | CA | San Bernardino | 6071001600 | 1102 | 1 | 0.92 | 0.69 | 0.73 | 0.73 | 0.24 | 0.30 | 23.37 | 0.95 | 4.56 |
| 19675111 | SOUTH FONTANA | CA | San Bernardino | 6071002609 | 722 | 0 | 0.88 | 0.29 | 0.42 | 0.42 | 0.13 | 0.86 | 21.69 | 0.85 | 3.84 |
| 14476111 | 31ST ST | CO | Denver | 8031001500 | 2247 | 1 | 0.97 | 0.44 | 0.97 | 0.97 | 0.18 | 0.33 | 22.23 | 0.88 | 4.74 |
| 14476811 | 36TH ST | CO | Denver | 8031003501 | 1800 | 1 | 0.88 | 0.50 | 0.99 | 0.99 | 0.17 | 0.15 | 21.20 | 0.79 | 4.46 |
| 14476911 | STERLING | CO | Logan | 8075966300 | 250 | 0 | 0.47 | 0.29 | 0.42 | 0.42 | 0.79 | 0.30 | 15.96 | 0.25 | 2.94 |
| 14477111 | GRAND JUNCTION | CO | Mesa | 8077000900 | 632 | 0 | 0.84 | 0.80 | 0.80 | 0.80 | 0.17 | 0.30 | 15.87 | 0.24 | 3.95 |
| 17862711 | COLORADO SPRINGS | CO | El Paso | 8041002300 | 1767 | 1 | 0.88 | 0.29 | 0.42 | 0.42 | 0.43 | 0.39 | 18.71 | 0.54 | 3.36 |
| 17867111 | LA SALLE | CO | Weld | 8123001700 | 76 | 1 | 0.24 | 0.88 | 0.87 | 0.87 | 0.38 | 0.41 | 19.26 | 0.60 | 4.25 |
| 17870911 | ROLLA | CO | Adams | 8001008535 | 708 | 0 | 0.18 | 0.29 | 0.42 | 0.42 | 0.06 | 0.30 | 17.31 | 0.37 | 2.04 |
| 17871011 | ROYDALE | CO | Denver | 8031004110 | 2211 | 0 | 0.94 | 0.55 | 0.60 | 0.60 | 0.01 | 0.74 | 12.29 | 0.03 | 3.48 |
| 19465311 | PLAINVIEW | CO | Jefferson | 8059009858 | 33 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.15 | 0.02 | 16.42 | 0.29 | 1.66 |
| 19465411 | FT. COLLINS | CO | Larimer | 8069001304 | 1825 | 1 | 0.64 | 0.55 | 0.60 | 0.60 | 0.56 | 0.41 | 18.97 | 0.57 | 3.94 |
| 19675011 | PUEBLO | CO | Pueblo | 8101000200 | 1574 | 1 | 0.76 | 0.55 | 0.60 | 0.60 | 0.50 | 0.47 | 17.86 | 0.42 | 3.91 |
| 14416311 | BENNING | DC | District of Columbia | 11001007708 | 7695 | 1 | 1.00 | 0.94 | 0.29 | 0.29 | 0.69 | 0.67 | 21.68 | 0.85 | 4.74 |
| 14416411 | BALDWIN | FL | Duval | 12031017300 | 72 | 0 | 0.24 | 0.94 | 0.29 | 0.29 | 0.53 | 0.92 | 18.27 | 0.48 | 3.70 |
| 14416511 | MONCRIEF | FL | Duval | 12031002701 | 2134 | 1 | 0.94 | 0.94 | 0.29 | 0.29 | 0.87 | 0.55 | 21.62 | 0.84 | 4.71 |
| 14416611 | SIMPSON | FL | Duval | 12031011700 | 482 | 1 | 0.82 | 0.49 | 0.55 | 0.55 | 0.88 | 0.20 | 20.75 | 0.75 | 4.24 |
| 14416811 | WEST JACKSONVILLE | FL | Duval | 12031012100 | 548 | 1 | 0.89 | 0.94 | 0.29 | 0.29 | 0.98 | 0.30 | 21.51 | 0.82 | 4.52 |
| 14416911 | GOULDING | FL | Escambia | 12033000600 | 2899 | 1 | 0.88 | 0.94 | 0.29 | 0.29 | 0.66 | 0.30 | 18.98 | 0.57 | 3.94 |
| 14417211 | ROCKPORT | FL | Hillsbor-ough | 12057013604 | 127 | 1 | 0.18 | 0.82 | 0.82 | 0.82 | 0.85 | 0.95 | 19.94 | 0.67 | 5.09 |
| 14417311 | UCETA | FL | Hillsbor-ough | 12057003700 | 468 | 1 | 0.69 | 0.94 | 0.29 | 0.29 | 0.35 | 0.98 | 22.83 | 0.92 | 4.47 |
| 14417411 | HIALEAH (CSXT) | FL | Miami-Dade | 12086000904 | 3298 | 1 | 0.88 | 0.94 | 0.29 | 0.29 | 0.58 | 0.72 | 20.03 | 0.67 | 4.37 |
| 14417611 | TAFT | FL | Orange | 12095016804 | 1012 | 0 | 0.47 | 0.94 | 0.29 | 0.29 | 0.14 | 0.69 | 16.38 | 0.29 | 3.10 |
| 14417711 | PIERCE | FL | Polk | 12105016100 | 8 | 1 | 0.07 | 0.94 | 0.29 | 0.29 | 0.88 | 0.17 | 21.00 | 0.77 | 3.41 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{2.5}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14417811 | AUBURNDALE | FL | Polk | 12105013200 | 2189 | 1 | 0.47 | 0.94 | 0.29 | 0.29 | 0.95 | 0.39 | 23.28 | 0.94 | 4.27 |
| 14417911 | PECAN | FL | Putnam | 12107950700 | 715 | 1 | 0.18 | 0.94 | 0.29 | 0.29 | 1.00 | 0.43 | 20.40 | 0.72 | 3.84 |
| 14418011 | WILDWOOD YARD | FL | Sumter | 12119911302 | 256 | 0 | 0.31 | 0.94 | 0.29 | 0.29 | 0.85 | 0.46 | 18.15 | 0.45 | 3.60 |
| 14478411 | YEOMAN | FL | Hillsbor-ough | 12057003700 | 468 | 1 | 0.59 | 0.94 | 0.29 | 0.29 | 0.35 | 0.98 | 22.83 | 0.92 | 4.36 |
| 14418111 | CARTERSVILLE | GA | Bartow | 13015960501 | 1890 | 0 | 0.18 | 0.94 | 0.29 | 0.29 | 0.58 | 0.36 | 18.59 | 0.53 | 3.17 |
| 14418411 | BROSNAN | GA | Bibb | 13021013900 | 57 | 1 | 0.24 | 0.65 | 1.00 | 1.00 | 0.81 | 0.47 | 19.93 | 0.67 | 4.84 |
| 14418511 | DILLARD | GA | Chatham | 13051010603 | 490 | 0 | 0.31 | 0.67 | 0.71 | 0.71 | 0.38 | 0.02 | 15.62 | 0.22 | 3.03 |
| 14418611 | SOUTHOVER | GA | Chatham | 13051004300 | 299 | 0 | 0.40 | 0.94 | 0.29 | 0.29 | 0.00 | 0.98 | 12.85 | 0.04 | 2.95 |
| 14419011 | INMAN | GA | Fulton | 13121008702 | 1592 | 1 | 0.64 | 0.61 | 0.99 | 0.99 | 0.40 | 0.58 | 18.86 | 0.56 | 4.78 |
| 14419211 | INDUSTRY | GA | Fulton | 13121011100 | 1887 | 0 | 0.78 | 0.41 | 0.50 | 0.50 | 0.17 | 0.02 | 17.70 | 0.40 | 2.79 |
| 14419411 | LANGDALE | GA | Lowndes | 13185010801 | 491 | 0 | 0.40 | 0.94 | 0.29 | 0.29 | 0.12 | 0.25 | 13.68 | 0.07 | 2.36 |
| 14419511 | COLUMBUS | GA | Muscogee | 13215011100 | 1664 | 0 | 0.59 | 0.50 | 0.55 | 0.55 | 0.66 | 0.39 | 18.51 | 0.52 | 3.77 |
| 14419811 | THOMASVILLE | GA | Thomas | 13275960800 | 88 | 0 | 0.53 | 0.94 | 0.29 | 0.29 | 0.72 | 0.46 | 17.97 | 0.44 | 3.67 |
| 14419911 | WAYCROSS | GA | Ware | 13299950900 | 29 | 0 | 0.18 | 0.22 | 0.91 | 0.91 | 0.76 | 0.39 | 18.40 | 0.50 | 3.86 |
| 14478611 | HOWELLS | GA | Fulton | 13121008905 | 2673 | 0 | 0.18 | 0.87 | 0.86 | 0.86 | 0.01 | 0.73 | 14.33 | 0.11 | 3.61 |
| 14478711 | HULSEY | GA | DeKalb | 13089020300 | 5451 | 1 | 0.80 | 0.94 | 0.29 | 0.29 | 0.06 | 0.72 | 18.84 | 0.56 | 3.66 |
| 14478811 | HULSEY | GA | Fulton | 13121003200 | 5842 | 0 | 0.89 | 0.94 | 0.29 | 0.29 | 0.01 | 0.72 | 13.04 | 0.05 | 3.19 |
| 18307011 | NORTH DORAVILLE | GA | DeKalb | 13089021306 | 2974 | 0 | 0.40 | 0.76 | 0.78 | 0.78 | 0.08 | 0.86 | 18.01 | 0.44 | 4.10 |
| 18307111 | KRANNERT | GA | Floyd | 13115001400 | 102 | 0 | 0.24 | 0.76 | 0.22 | 0.22 | 0.56 | 0.92 | 16.53 | 0.30 | 3.22 |
| 18307211 | AUGUSTA (NS) | GA | Richmond | 13245010602 | 88 | 1 | 0.59 | 0.65 | 0.69 | 0.69 | 0.03 | 0.64 | 19.38 | 0.61 | 3.91 |
| 18307411 | TOCCOA | GA | Stephens | 13257970301 | 685 | 1 | 0.18 | 0.76 | 0.78 | 0.78 | 0.91 | 0.48 | 19.34 | 0.61 | 4.49 |
| 18338611 | AUSTELL | GA | Cobb | 13067031416 | 1096 | 0 | 0.47 | 0.00 | 0.00 | 0.00 | 0.12 | 0.15 | 15.94 | 0.24 | 0.98 |
| 18338711 | BRUNSWICK | GA | Glynn | 13127000702 | 1026 | 1 | 0.18 | 0.64 | 0.21 | 0.21 | 0.72 | 0.51 | 19.68 | 0.65 | 3.11 |
| 18338811 | VALDOSTA | GA | Lowndes | 13185010801 | 491 | 1 | 0.31 | 0.41 | 0.50 | 0.50 | 0.96 | 0.66 | 19.64 | 0.65 | 3.99 |
| 14427611 | WATERLOO (CN) | IA | Black Hawk | 19013001800 | 1659 | 1 | 0.59 | 0.63 | 0.67 | 0.67 | 0.89 | 0.64 | 16.96 | 0.34 | 4.43 |
| 14427811 | MASON CITY | IA | Cerro Gordo | 19033950202 | 296 | 0 | 0.24 | 0.80 | 0.80 | 0.80 | 0.60 | 0.83 | 16.79 | 0.32 | 4.40 |
| 14428011 | CLINTON | IA | Clinton | 19045000400 | 254 | 0 | 0.24 | 0.69 | 0.73 | 0.73 | 0.66 | 0.83 | 18.39 | 0.50 | 4.38 |
| 14428211 | DUBUQUE | IA | Dubuque | 19061000801 | 1353 | 0 | 0.64 | 0.73 | 0.76 | 0.76 | 0.50 | 0.74 | 12.58 | 0.04 | 4.17 |
| 14428611 | FT. MADISON | IA | Lee | 19111490200 | 227 | 1 | 0.40 | 0.73 | 0.76 | 0.76 | 0.48 | 0.92 | 18.49 | 0.52 | 4.57 |
| 14428911 | HULL AVE YARD | IA | Polk | 19153000300 | 1733 | 1 | 0.80 | 0.55 | 0.60 | 0.60 | 0.56 | 0.98 | 18.19 | 0.46 | 4.56 |
| 14429411 | SIOUX CITY (18TH STREET) | IA | Woodbury | 19193000100 | 507 | 0 | 0.53 | 0.73 | 0.75 | 0.75 | 0.33 | 0.28 | 14.56 | 0.13 | 3.49 |
| 14479211 | MARSHALL-TOWN | IA | Marshall | 19127950900 | 692 | 1 | 0.73 | 0.84 | 0.84 | 0.84 | 0.58 | 0.30 | 19.51 | 0.62 | 4.76 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{2.5}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14479311 | SIOUX CITY (28TH STREET) | IA | Woodbury | 19193000100 | 507 | 0 | 0.64 | 0.80 | 0.80 | 0.80 | 0.33 | 0.28 | 14.56 | 0.13 | 3.77 |
| 17861211 | BEVERLY | IA | Linn | 19113003005 | 1586 | 0 | 0.18 | 0.55 | 0.60 | 0.60 | 0.14 | 0.78 | 13.39 | 0.06 | 2.92 |
| 17861711 | BOONE | IA | Boone | 19015020300 | 1423 | 0 | 0.40 | 0.88 | 0.87 | 0.87 | 0.43 | 0.92 | 14.01 | 0.09 | 4.45 |
| 17862211 | CEDAR RAPIDS | IA | Linn | 19113001300 | 1848 | 0 | 0.80 | 0.29 | 0.42 | 0.42 | 0.18 | 0.20 | 16.61 | 0.31 | 2.63 |
| 17863511 | EAGLE GROVE | IA | Wright | 19197680500 | 376 | 0 | 0.31 | 0.55 | 0.60 | 0.60 | 0.66 | 0.81 | 14.72 | 0.14 | 3.69 |
| 17864911 | FT DODGE | IA | Webster | 19187000500 | 114 | 0 | 0.53 | 0.29 | 0.42 | 0.42 | 0.74 | 0.06 | 16.54 | 0.30 | 2.76 |
| 17866011 | IOWA FALLS | IA | Hardin | 19083480200 | 53 | 0 | 0.40 | 0.55 | 0.60 | 0.60 | 0.74 | 0.81 | 18.99 | 0.57 | 4.28 |
| 17869311 | NORTH COUNCIL BLUFFS | IA | Pottawat-tamie | 19155030200 | 2215 | 0 | 0.64 | 0.36 | 0.93 | 0.93 | 0.22 | 0.06 | 16.26 | 0.27 | 3.42 |
| 17871811 | SHORTLINE YARD | IA | Polk | 19153005300 | 454 | 1 | 0.53 | 0.36 | 0.93 | 0.93 | 0.38 | 0.11 | 17.68 | 0.40 | 3.65 |
| 18305611 | NAHANT | IA | Scott | 19163012400 | 154 | 0 | 0.24 | 0.40 | 0.49 | 0.49 | 0.45 | 0.98 | 17.57 | 0.39 | 3.45 |
| 18338911 | CLINTON | IA | Clinton | 19045000200 | 287 | 1 | 0.40 | 0.35 | 0.48 | 0.48 | 0.72 | 0.20 | 20.16 | 0.68 | 3.31 |
| 18339011 | DUBUQUE | IA | Dubuque | 19061000500 | 8135 | 1 | 0.69 | 0.77 | 0.23 | 0.23 | 0.56 | 0.48 | 19.22 | 0.60 | 3.56 |
| 18339111 | MASON CITY (CP) | IA | Cerro Gordo | 19033950402 | 1657 | 0 | 0.69 | 0.40 | 0.49 | 0.49 | 0.77 | 0.11 | 16.05 | 0.25 | 3.21 |
| 19466511 | CLEAR CREEK | IA | Story | 19169010200 | 30 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.31 | 0.75 | 14.14 | 0.09 | 2.35 |
| 19466611 | HANLONTOWN | IA | Worth | 19195690200 | 11 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.45 | 0.75 | 13.01 | 0.05 | 2.45 |
| 19675211 | FT. DODGE | IA | Webster | 19187000600 | 3519 | 0 | 0.59 | 0.29 | 0.42 | 0.42 | 0.45 | 0.02 | 16.03 | 0.25 | 2.44 |
| 19675311 | WILLOW CREEK | IA | Harrison | 19085290400 | 466 | 1 | 0.31 | 0.29 | 0.42 | 0.42 | 0.76 | 0.11 | 16.97 | 0.34 | 2.66 |
| 14420211 | POCATELLO | ID | Bannock | 16005001603 | 1045 | 0 | 0.69 | 0.22 | 0.92 | 0.92 | 0.15 | 0.45 | 15.36 | 0.20 | 3.55 |
| 14420311 | MONTPELIER | ID | Bear Lake | 16007950100 | 7 | 0 | 0.40 | 0.80 | 0.80 | 0.80 | 0.81 | 0.25 | 14.04 | 0.09 | 3.93 |
| 14421011 | IDAHO FALLS | ID | Bonneville | 16019970700 | 1864 | 1 | 0.84 | 0.69 | 0.73 | 0.73 | 0.43 | 0.51 | 17.33 | 0.37 | 4.30 |
| 14421311 | UNION PACIFIC NAMPA | ID | Canyon | 16027020405 | 3909 | 1 | 0.86 | 0.88 | 0.87 | 0.87 | 0.33 | 0.39 | 18.75 | 0.55 | 4.74 |
| 17871411 | SANDPOINT | ID | Bonner | 16017950203 | 401 | 0 | 0.59 | 0.29 | 0.42 | 0.42 | 0.45 | 0.20 | 14.71 | 0.14 | 2.52 |
| 19465611 | MICHAUD | ID | Power | 16077960100 | 2 | 1 | 0.07 | 0.55 | 0.60 | 0.60 | 0.87 | 0.45 | 17.51 | 0.39 | 3.53 |
| 19465711 | MOUNTAIN HOME | ID | Elmore | 16039960300 | 38 | 1 | 0.76 | 0.29 | 0.42 | 0.42 | 0.50 | 0.28 | 18.21 | 0.47 | 3.13 |
| 19465811 | COLLINS | ID | Bingham | 16011950600 | 169 | 0 | 0.47 | 0.29 | 0.42 | 0.42 | 0.48 | 0.36 | 15.23 | 0.19 | 2.62 |
| 19465911 | EPCO | ID | Caribou | 16029960200 | 3 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.53 | 0.20 | 16.30 | 0.27 | 2.21 |
| 19466011 | COBB | ID | Washing-ton | 16087970300 | 15 | 1 | 0.07 | 0.29 | 0.42 | 0.42 | 0.93 | 0.39 | 17.48 | 0.38 | 2.89 |
| 5417811 | ADM RAIL CAR REPAIR FACILITY | IL | Macon | 17115002100 | 333 | 0 | 0.64 | 0.46 | 0.35 | 0.35 | 0.85 | 0.45 | 19.99 | 0.67 | 3.76 |
| 14422011 | BARR | IL | Cook | 17031821500 | 791 | 1 | 0.97 | 1.00 | 0.89 | 0.89 | 0.24 | 0.64 | 21.80 | 0.86 | 5.50 |
| 14422111 | BENSENVILLE | IL | Cook | 17031811701 | 1235 | 1 | 0.80 | 0.44 | 0.53 | 0.53 | 0.22 | 0.86 | 21.36 | 0.80 | 4.18 |
| 14422211 | CALUMET | IL | Cook | 17031838800 | 371 | 1 | 0.80 | 0.81 | 0.81 | 0.81 | 0.65 | 0.48 | 23.57 | 0.95 | 5.32 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{2.5}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14422311 | CHICAGO 47TH STREET | IL | Cook | 17031843800 | 3956 | 1 | 0.99 | 0.62 | 0.67 | 0.67 | 0.43 | 0.41 | 21.82 | 0.86 | 4.65 |
| 14422511 | MARKHAM | IL | Cook | 17031827500 | 1684 | 1 | 0.76 | 0.73 | 0.76 | 0.76 | 0.48 | 0.46 | 20.61 | 0.74 | 4.68 |
| 14422611 | CICERO | IL | Cook | 17031814100 | 9362 | 1 | 0.98 | 0.39 | 0.95 | 0.95 | 0.17 | 0.92 | 20.85 | 0.76 | 5.11 |
| 14422711 | GLOBAL I | IL | Cook | 17031842900 | 2912 | 1 | 1.00 | 0.55 | 0.60 | 0.60 | 0.85 | 0.61 | 23.33 | 0.94 | 5.16 |
| 14423011 | PROVISO | IL | Cook | 17031816800 | 3129 | 0 | 0.88 | 0.46 | 0.97 | 0.97 | 0.35 | 0.83 | 21.04 | 0.77 | 5.24 |
| 14423211 | YARD CENTER | IL | Cook | 17031826500 | 4048 | 1 | 0.98 | 0.38 | 0.95 | 0.95 | 0.31 | 0.56 | 22.43 | 0.90 | 5.02 |
| 14423311 | FICKLIN | IL | Douglas | 17041952400 | 60 | 0 | 0.07 | 0.42 | 0.52 | 0.52 | 0.74 | 0.17 | 17.29 | 0.37 | 2.80 |
| 14423711 | GALESBURG | IL | Knox | 17095001000 | 1369 | 0 | 0.18 | 0.75 | 0.86 | 0.86 | 0.87 | 0.48 | 19.09 | 0.59 | 4.59 |
| 14423811 | DECATUR | IL | Macon | 17115001100 | 1053 | 0 | 0.31 | 0.65 | 1.00 | 1.00 | 0.60 | 0.20 | 16.89 | 0.34 | 4.11 |
| 14424411 | IOWA JCT. | IL | Peoria | 17143005100 | 1103 | 0 | 0.59 | 0.40 | 0.49 | 0.49 | 0.74 | 0.67 | 18.45 | 0.51 | 3.89 |
| 14424711 | ROSELAKE | IL | St. Clair | 17163502100 | 491 | 1 | 0.31 | 0.61 | 0.66 | 0.66 | 0.66 | 0.20 | 20.95 | 0.77 | 3.89 |
| 14425311 | BREWER | IL | Vermilion | 17183011200 | 845 | 0 | 0.24 | 0.61 | 0.66 | 0.66 | 0.69 | 0.39 | 17.88 | 0.42 | 3.69 |
| 14466111 | GLENN | IL | Cook | 17031820800 | 1584 | 0 | 0.88 | 0.86 | 0.85 | 0.85 | 0.29 | 0.77 | 19.67 | 0.65 | 5.15 |
| 14479911 | CENTRALIA (CN) | IL | Washing-ton | 17189950100 | 19 | 0 | 0.31 | 0.63 | 0.67 | 0.67 | 0.56 | 0.02 | 16.46 | 0.29 | 3.16 |
| 14480111 | CORWITH | IL | Cook | 17031570100 | 2244 | 1 | 0.99 | 0.38 | 0.94 | 0.94 | 0.22 | 0.83 | 20.36 | 0.71 | 5.02 |
| 14480311 | EAST ST LOUIS | IL | St. Clair | 17163504501 | 1188 | 1 | 0.64 | 0.63 | 0.68 | 0.68 | 0.82 | 0.67 | 21.27 | 0.80 | 4.92 |
| 14480511 | GLOBAL III | IL | Ogle | 17141961600 | 280 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.38 | 0.28 | 16.78 | 0.32 | 2.81 |
| 14480611 | GLOBAL II | IL | Cook | 17031816500 | 3172 | 1 | 0.92 | 0.55 | 0.60 | 0.60 | 0.40 | 0.98 | 22.62 | 0.91 | 4.98 |
| 14480711 | CHICAGO HEIGHTS | IL | Cook | 17031829500 | 1989 | 1 | 0.84 | 0.80 | 0.80 | 0.80 | 0.74 | 0.17 | 21.18 | 0.78 | 4.93 |
| 14480811 | LANDERS | IL | Cook | 17031700100 | 3717 | 0 | 0.97 | 0.22 | 0.36 | 0.36 | 0.15 | 0.39 | 18.61 | 0.54 | 2.97 |
| 14480911 | MADISON (UP) | IL | Madison | 17119400903 | 220 | 0 | 0.59 | 0.55 | 0.60 | 0.60 | 0.53 | 0.33 | 18.38 | 0.49 | 3.70 |
| 14481011 | MARKHAM | IL | Cook | 17031827300 | 3616 | 1 | 0.93 | 0.29 | 0.42 | 0.42 | 0.69 | 0.57 | 21.78 | 0.86 | 4.18 |
| 14481111 | PARIS (MIDLAND) | IL | Edgar | 17045070300 | 201 | 0 | 0.47 | 0.42 | 0.52 | 0.52 | 0.74 | 0.11 | 17.70 | 0.40 | 3.18 |
| 14481411 | SALEM | IL | Marion | 17121951600 | 22 | 0 | 0.18 | 0.29 | 0.42 | 0.42 | 0.60 | 0.02 | 17.43 | 0.38 | 2.30 |
| 14481511 | TILTON | IL | Vermilion | 17183010701 | 443 | 0 | 0.47 | 0.78 | 0.23 | 0.23 | 0.94 | 0.28 | 18.17 | 0.46 | 3.38 |
| 15527311 | ROODHOUSE | IL | Greene | 17061973700 | 354 | 0 | 0.18 | 0.98 | 0.34 | 0.34 | 0.91 | 0.33 | 17.48 | 0.38 | 3.45 |
| 17861111 | BELVIDERE | IL | Boone | 17007010400 | 82 | 0 | 0.07 | 0.69 | 0.73 | 0.73 | 0.31 | 0.83 | 19.36 | 0.61 | 3.97 |
| 17863411 | DUPO | IL | St. Clair | 17163503102 | 390 | 0 | 0.31 | 0.55 | 0.60 | 0.60 | 0.53 | 0.28 | 20.06 | 0.68 | 3.56 |
| 17869211 | NORTH AVE | IL | Cook | 17031842300 | 4860 | 0 | 0.99 | 0.29 | 0.42 | 0.42 | 0.05 | 0.69 | 15.96 | 0.24 | 3.11 |
| 17874711 | WEST CHICAGO | IL | DuPage | 17043841501 | 1101 | 0 | 0.69 | 0.80 | 0.80 | 0.80 | 0.33 | 0.11 | 19.24 | 0.60 | 4.13 |
| 18306411 | BEDFORD PARK | IL | Cook | 17031820901 | 1250 | 0 | 0.96 | 0.35 | 0.93 | 0.93 | 0.40 | 0.92 | 20.58 | 0.74 | 5.23 |
| 18306511 | OTTAWA | IL | La Salle | 17099962200 | 41 | 0 | 0.18 | 0.42 | 0.52 | 0.52 | 0.40 | 0.86 | 15.34 | 0.20 | 3.09 |
| 18307711 | FEDERAL | IL | Madison | 17119402400 | 449 | 1 | 0.40 | 0.89 | 0.25 | 0.25 | 0.88 | 0.48 | 20.26 | 0.70 | 3.85 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18312611 | LOGISTICS PARK CHICAGO (LPC) | IL | Will | 17197883306 | 131 | 0 | 0.07 | 0.38 | 0.95 | 0.95 | 0.11 | 0.83 | 13.77 | 0.08 | 3.37 |
| 18314611 | CHESTER | IL | Randolph | 17157951300 | 181 | 0 | 0.18 | 0.80 | 0.80 | 0.80 | 0.56 | 0.02 | 17.35 | 0.37 | 3.52 |
| 18339311 | AO SMITH | IL | Madison | 17119400200 | 738 | 1 | 0.59 | 0.83 | 0.83 | 0.83 | 0.76 | 0.45 | 21.99 | 0.87 | 5.14 |
| 18339411 | ASHLAND AVENUE | IL | Cook | 17031610300 | 5883 | 1 | 0.99 | 0.62 | 0.67 | 0.67 | 0.21 | 0.06 | 23.77 | 0.96 | 4.18 |
| 18339511 | BLUE ISLAND | IL | Cook | 17031826800 | 1498 | 1 | 0.97 | 0.20 | 0.90 | 0.90 | 0.38 | 0.39 | 23.24 | 0.94 | 4.68 |
| 18339611 | CENTRALIA | IL | Marion | 17121952700 | 978 | 1 | 0.64 | 0.20 | 0.20 | 0.20 | 0.96 | 0.55 | 20.26 | 0.70 | 3.44 |
| 18339711 | CHICAGO 59TH STREET | IL | Cook | 17031835100 | 14365 | 1 | 1.00 | 0.42 | 0.52 | 0.52 | 0.16 | 0.11 | 22.58 | 0.91 | 3.63 |
| 18339811 | CHICAGO 63RD STREET | IL | Cook | 17031842500 | 6399 | 1 | 0.99 | 0.78 | 0.23 | 0.23 | 0.38 | 0.67 | 22.01 | 0.87 | 4.16 |
| 18339911 | CLEARING | IL | Cook | 17031820901 | 1250 | 0 | 0.93 | 0.39 | 0.95 | 0.95 | 0.40 | 0.92 | 20.58 | 0.74 | 5.29 |
| 18340011 | DECATUR (CSXT) | IL | Macon | 17115000200 | 4160 | 1 | 0.69 | 0.67 | 0.71 | 0.71 | 0.89 | 0.64 | 20.27 | 0.70 | 5.01 |
| 18340311 | KANKAKEE | IL | Kankakee | 17091012100 | 1880 | 0 | 0.47 | 0.64 | 0.69 | 0.69 | 0.72 | 0.92 | 14.85 | 0.15 | 4.27 |
| 18340411 | MADISON (TRRA) | IL | Madison | 17119400700 | 807 | 1 | 0.59 | 0.21 | 0.91 | 0.91 | 0.79 | 0.65 | 21.22 | 0.79 | 4.85 |
| 18700711 | CHAMPAIGN | IL | Cham-paign | 17019000800 | 1265 | 0 | 0.59 | 0.63 | 0.67 | 0.67 | 0.45 | 0.98 | 14.84 | 0.15 | 4.15 |
| 18700811 | DECATUR | IL | Macon | 17115003100 | 1846 | 0 | 0.76 | 0.63 | 0.67 | 0.67 | 0.74 | 0.66 | 18.13 | 0.45 | 4.58 |
| 18700911 | EAST JOLIET | IL | Will | 17197882100 | 5213 | 0 | 0.88 | 0.63 | 0.67 | 0.67 | 0.24 | 0.30 | 20.22 | 0.69 | 4.09 |
| 18701111 | HAWTHORNE | IL | Cook | 17031814300 | 13360 | 1 | 0.97 | 0.47 | 0.98 | 0.98 | 0.29 | 0.95 | 22.79 | 0.91 | 5.55 |
| 19466111 | SHERMER | IL | Cook | 17031801608 | 2654 | 0 | 0.84 | 0.29 | 0.42 | 0.42 | 0.27 | 0.68 | 15.02 | 0.17 | 3.08 |
| 19466211 | WATSEKA | IL | Iroquois | 17075950400 | 748 | 0 | 0.40 | 0.55 | 0.60 | 0.60 | 0.96 | 0.33 | 19.65 | 0.65 | 4.09 |
| 19466311 | NELSON | IL | Lee | 17103000700 | 11 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.69 | 0.95 | 16.89 | 0.34 | 3.80 |
| 19466411 | PONTIAC | IL | Livingston | 17105960700 | 969 | 0 | 0.53 | 0.55 | 0.60 | 0.60 | 0.50 | 0.89 | 16.38 | 0.28 | 3.97 |
| 19675411 | DOLTON JCT | IL | Cook | 17031826500 | 4048 | 1 | 0.98 | 0.55 | 0.60 | 0.60 | 0.31 | 0.56 | 22.43 | 0.90 | 4.51 |
| 19675511 | GRAND AVENUE | IL | Cook | 17031811702 | 5105 | 1 | 0.86 | 0.29 | 0.42 | 0.42 | 0.33 | 0.83 | 21.39 | 0.81 | 3.96 |
| 14417511 | HAWTHORNE | IN | Marion | 18097361200 | 3429 | 0 | 0.59 | 0.61 | 0.66 | 0.66 | 0.60 | 0.43 | 18.27 | 0.48 | 4.04 |
| 14425611 | EAST WAYNE | IN | Allen | 18003011201 | 563 | 1 | 0.31 | 0.46 | 0.97 | 0.97 | 0.87 | 0.62 | 20.79 | 0.75 | 4.97 |
| 14425711 | FRANKFORT | IN | Clinton | 18023950400 | 37 | 0 | 0.31 | 0.45 | 0.20 | 0.20 | 0.53 | 0.11 | 14.36 | 0.11 | 1.93 |
| 14425811 | GARRETT | IN | De Kalb | 18033020601 | 258 | 0 | 0.31 | 0.67 | 0.71 | 0.71 | 0.45 | 0.33 | 16.37 | 0.28 | 3.46 |
| 14425911 | EAST YARD | IN | Delaware | 18035001200 | 1508 | 0 | 0.47 | 0.19 | 0.19 | 0.19 | 0.94 | 0.66 | 18.36 | 0.49 | 3.13 |
| 14426111 | ELKHART | IN | Elkhart | 18039001402 | 998 | 0 | 0.53 | 0.65 | 1.00 | 1.00 | 0.48 | 0.15 | 14.50 | 0.12 | 3.92 |
| 14426311 | ALICE | IN | Knox | 18083955500 | 2234 | 1 | 0.53 | 0.42 | 0.52 | 0.52 | 0.89 | 0.43 | 20.10 | 0.68 | 3.98 |
| 14426511 | GIBSON | IN | Lake | 18089020800 | 2776 | 1 | 0.78 | 0.19 | 0.19 | 0.19 | 0.81 | 0.63 | 20.96 | 0.77 | 3.57 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14426911 | EAST YARD | IN | Tippeca-noe | 18157001900 | 1828 | 0 | 0.53 | 0.65 | 0.69 | 0.69 | 0.58 | 0.36 | 15.02 | 0.17 | 3.67 |
| 14427011 | LAFAYETTE | IN | Tippeca-noe | 18157000100 | 1840 | 1 | 0.64 | 0.75 | 0.78 | 0.78 | 0.35 | 0.50 | 19.46 | 0.62 | 4.42 |
| 14427111 | HOWELL | IN | Vander-burgh | 18163003100 | 2608 | 1 | 0.31 | 0.83 | 0.83 | 0.83 | 0.43 | 0.36 | 18.90 | 0.56 | 4.15 |
| 14427211 | WANSFORD YARD | IN | Vander-burgh | 18163003500 | 1303 | 0 | 0.64 | 0.94 | 0.29 | 0.29 | 0.52 | 0.20 | 16.13 | 0.26 | 3.15 |
| 14427311 | BAKER | IN | Vigo | 18167001700 | 2905 | 1 | 0.76 | 0.94 | 0.29 | 0.29 | 0.85 | 0.56 | 18.90 | 0.56 | 4.24 |
| 14427411 | DUANE | IN | Vigo | 18167001100 | 3030 | 1 | 0.53 | 0.94 | 0.29 | 0.29 | 0.82 | 0.60 | 19.68 | 0.65 | 4.12 |
| 14481811 | AVON | IN | Hendricks | 18063210614 | 1401 | 0 | 0.64 | 0.39 | 0.95 | 0.95 | 0.13 | 0.11 | 15.01 | 0.17 | 3.34 |
| 14481911 | EAST CHICAGO | IN | Lake | 18089030500 | 8083 | 1 | 0.64 | 0.94 | 0.29 | 0.29 | 0.58 | 0.50 | 21.95 | 0.87 | 4.11 |
| 14482011 | IVANHOE | IN | Lake | 18089021000 | 2343 | 1 | 0.59 | 0.77 | 0.22 | 0.22 | 0.40 | 0.39 | 19.10 | 0.59 | 3.18 |
| 18306611 | SOUTH ANDERSON | IN | Madison | 18095001901 | 2777 | 1 | 0.53 | 0.94 | 0.29 | 0.29 | 0.91 | 0.50 | 19.45 | 0.62 | 4.08 |
| 18307911 | ROANOKE (GM) | IN | Allen | 18003011701 | 123 | 0 | 0.18 | 0.71 | 0.21 | 0.21 | 0.31 | 0.20 | 12.19 | 0.03 | 1.85 |
| 18308111 | GOODMAN | IN | Grant | 18053010100 | 72 | 0 | 0.31 | 0.98 | 0.33 | 0.33 | 0.63 | 0.15 | 14.16 | 0.10 | 2.83 |
| 18308311 | BURNS HARBOR | IN | Porter | 18127980002 | 0 | 0 | 0.07 | 0.74 | 0.76 | 0.76 | NA | NA | 3.45 | 0.00 | NA |
| 14429811 | ATCHISON | KS | Atchison | 20005081900 | 3325 | 1 | 0.40 | 0.29 | 0.42 | 0.42 | 0.77 | 0.43 | 18.25 | 0.48 | 3.20 |
| 14430011 | WINFIELD | KS | Cowley | 20035493400 | 206 | 1 | 0.31 | 0.22 | 0.36 | 0.36 | 0.81 | 0.15 | 18.43 | 0.50 | 2.70 |
| 14430111 | HERINGTON | KS | Dickinson | 20041084600 | 372 | 1 | 0.31 | 0.84 | 0.84 | 0.84 | 0.96 | 0.41 | 18.12 | 0.45 | 4.65 |
| 14430511 | NEWTON | KS | Harvey | 20079030300 | 583 | 0 | 0.59 | 0.41 | 0.50 | 0.50 | 0.58 | 0.06 | 16.49 | 0.29 | 2.93 |
| 14430911 | COLDSPUR | KS | Wyandotte | 20103071400 | 51 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.48 | 0.98 | 14.98 | 0.16 | 2.82 |
| 14431011 | EMPORIA | KS | Lyon | 20111000300 | 780 | 1 | 0.59 | 0.48 | 0.54 | 0.54 | 0.38 | 0.28 | 18.59 | 0.53 | 3.33 |
| 14431411 | HUTCHINSON | KS | Reno | 20155001100 | 165 | 0 | 0.07 | 0.41 | 0.50 | 0.50 | 0.50 | 0.92 | 14.93 | 0.16 | 3.05 |
| 14431711 | SALINA | KS | Saline | 20169000200 | 311 | 1 | 0.53 | 0.69 | 0.73 | 0.73 | 0.85 | 0.51 | 18.89 | 0.56 | 4.60 |
| 14431911 | WICHITA | KS | Sedgwick | 20173008100 | 407 | 0 | 0.73 | 0.22 | 0.92 | 0.92 | 0.66 | 0.02 | 15.96 | 0.24 | 3.71 |
| 14482211 | ARGENTINE YARD | KS | Wyandotte | 20209981500 | 3 | 0 | 0.53 | 0.49 | 0.99 | 0.99 | NA | NA | 8.76 | 0.01 | NA |
| 14482511 | NORTH TOPEKA | KS | Shawnee | 20177000700 | 434 | 1 | 0.64 | 0.55 | 0.60 | 0.60 | 0.56 | 0.43 | 19.11 | 0.59 | 3.98 |
| 15527411 | PITTSBURG | KS | Crawford | 20037957000 | 415 | 0 | 0.59 | 0.98 | 0.34 | 0.34 | 0.35 | 0.15 | 15.25 | 0.19 | 2.94 |
| 17863811 | 18TH STREET | KS | Wyandotte | 20209981200 | 6 | 0 | 0.82 | 0.36 | 0.93 | 0.93 | NA | NA | 9.18 | 0.01 | NA |
| 17864511 | FAIRFAX | KS | Wyandotte | 20209980000 | 0 | 0 | 0.69 | 0.36 | 0.93 | 0.93 | NA | NA | 3.81 | 0.00 | NA |
| 17867711 | LIBERAL | KS | Seward | 20175966000 | 1200 | 0 | 0.59 | 0.29 | 0.42 | 0.42 | 0.20 | 0.30 | 16.73 | 0.32 | 2.54 |
| 17869611 | OAKLEY | KS | Logan | 20109954600 | 3 | 0 | 0.31 | 0.55 | 0.60 | 0.60 | 0.85 | 0.06 | 15.36 | 0.20 | 3.18 |
| 17875911 | MUNCIE | KS | Wyandotte | 20209044002 | 509 | 1 | 0.24 | 0.29 | 0.42 | 0.42 | 0.02 | 0.57 | 20.09 | 0.68 | 2.64 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18313011 | LOGISTICS PARK KANSAS CITY (LPKC) | KS | Johnson | 20091053712 | 208 | 0 | 0.07 | 0.73 | 0.76 | 0.76 | 0.11 | 0.06 | 12.19 | 0.03 | 2.52 |
| 18701511 | HUTCHINSON | KS | Reno | 20155000800 | 692 | 1 | 0.73 | 0.69 | 0.73 | 0.73 | 0.38 | 0.17 | 18.39 | 0.49 | 3.92 |
| 19466711 | BLOOM | KS | Ford | 20057961700 | 3 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.65 | 0.95 | 13.98 | 0.08 | 2.88 |
| 19466811 | MARYSVILLE | KS | Marshall | 20117060510 | 103 | 0 | 0.24 | 0.55 | 0.60 | 0.60 | 0.87 | 0.06 | 15.08 | 0.18 | 3.11 |
| 13422811 | PROGRESS RAIL SERVICES CORP | KY | Graves | 21083020200 | 221 | 0 | 0.18 | 0.78 | 0.67 | 0.66 | 0.99 | 0.50 | 18.06 | 0.44 | 4.22 |
| 14432511 | DANVILLE | KY | Boyle | 21021930500 | 96 | 0 | 0.76 | 0.61 | 0.66 | 0.66 | 0.56 | 0.02 | 14.54 | 0.12 | 3.38 |
| 14432611 | FULTON | KY | Fulton | 21075960100 | 42 | 1 | 0.31 | 0.50 | 0.55 | 0.55 | 0.02 | 0.60 | 20.87 | 0.76 | 3.29 |
| 14432711 | RUSSELL | KY | Greenup | 21089040300 | 724 | 0 | 0.47 | 0.94 | 0.29 | 0.29 | 0.79 | 0.51 | 18.24 | 0.47 | 3.77 |
| 14432811 | LOYALL | KY | Harlan | 21095970700 | 203 | 1 | 0.31 | 0.94 | 0.29 | 0.29 | 1.00 | 0.60 | 20.37 | 0.71 | 4.15 |
| 14482611 | CORBIN | KY | Whitley | 21235920200 | 725 | 0 | 0.73 | 0.94 | 0.29 | 0.29 | 0.89 | 0.50 | 18.52 | 0.52 | 4.16 |
| 14498811 | BEUCHEL | KY | Jefferson | 21111011301 | 904 | 1 | 0.89 | 0.37 | 0.48 | 0.48 | 0.74 | 0.55 | 19.31 | 0.61 | 4.12 |
| 14499011 | YOUNGSTOWN | KY | Jefferson | 21111000300 | 3741 | 1 | 0.76 | 0.37 | 0.48 | 0.48 | 0.88 | 0.65 | 20.35 | 0.71 | 4.33 |
| 14499211 | CSX TRANS-PORTATION OSBORN SWITCHYARD | KY | Jefferson | 21111980100 | 2 | 0 | 0.31 | 0.40 | 0.96 | 0.96 | NA | NA | 4.26 | 0.00 | NA |
| 18308611 | LOUISVILLE - APPLIANCE PARK | KY | Jefferson | 21111011006 | 1852 | 1 | 0.84 | 0.86 | 0.85 | 0.85 | 0.69 | 0.57 | 20.93 | 0.76 | 5.43 |
| 18308811 | SHELBYVILLE MIXING CENTER | KY | Shelby | 21211040404 | 377 | 0 | 0.24 | 0.47 | 0.53 | 0.53 | 0.45 | 0.33 | 16.94 | 0.34 | 2.90 |
| 14415811 | GEISMAR | LA | Ascension | 22005030302 | 115 | 0 | 0.07 | 0.86 | 0.85 | 0.85 | 0.11 | 0.81 | 15.97 | 0.25 | 3.81 |
| 14433911 | DERAMUS | LA | Caddo | 22017024602 | 698 | 0 | 0.31 | 0.90 | 0.89 | 0.89 | 0.81 | 0.61 | 20.23 | 0.69 | 5.09 |
| 14434111 | BATON ROUGE (CN) | LA | East Baton Rouge | 22033003000 | 276 | 1 | 0.73 | 0.82 | 0.82 | 0.82 | 0.17 | 0.64 | 21.34 | 0.80 | 4.81 |
| 14434311 | MAYS | LA | Jefferson | 22051028900 | 1676 | 0 | 0.73 | 0.89 | 0.88 | 0.88 | 0.31 | 0.89 | 19.03 | 0.58 | 5.16 |
| 14434711 | MONROE (UP) | LA | Ouachita | 22073001400 | 1219 | 1 | 0.82 | 0.29 | 0.42 | 0.42 | 0.91 | 0.62 | 21.27 | 0.80 | 4.28 |
| 14434811 | LIVONIA | LA | Pointe Coupee | 22077952400 | 42 | 0 | 0.18 | 0.88 | 0.87 | 0.87 | 0.66 | 0.33 | 19.98 | 0.67 | 4.46 |
| 14434911 | ALEXANDRIA | LA | Rapides | 22079012800 | 686 | 1 | 0.59 | 0.84 | 0.84 | 0.84 | 0.91 | 0.58 | 21.44 | 0.81 | 5.41 |
| 14482911 | SHREWSBURY | LA | Jefferson | 22051028900 | 1676 | 0 | 0.76 | 0.49 | 0.55 | 0.55 | 0.31 | 0.69 | 16.31 | 0.28 | 3.62 |
| 15527611 | LAKE CHARLES (MOSSVILLE) | LA | Calcasieu | 22019002702 | 157 | 0 | 0.07 | 0.63 | 0.68 | 0.68 | 0.60 | 0.25 | 18.46 | 0.51 | 3.43 |
| 15527811 | LATANIER | LA | Rapides | 22079013300 | 28 | 0 | 0.07 | 0.98 | 0.34 | 0.34 | 0.66 | 0.28 | 19.62 | 0.64 | 3.32 |
| 15527911 | RESERVE | LA | St. John the Baptist | 22095070700 | 314 | 0 | 0.18 | 0.98 | 0.34 | 0.34 | 0.91 | 0.25 | 20.32 | 0.71 | 3.70 |
| 15528011 | LEESVILLE | LA | Vernon | 22115950501 | 810 | 0 | 0.47 | 0.98 | 0.34 | 0.34 | 0.45 | 0.39 | 18.86 | 0.56 | 3.52 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17860211 | ADDIS | LA | West Baton Rouge | 22121020401 | 290 | 0 | 0.18 | 0.55 | 0.60 | 0.60 | 0.29 | 0.20 | 19.56 | 0.64 | 3.06 |
| 17870611 | REISOR | LA | Caddo | 22017024304 | 133 | 0 | 0.07 | 0.21 | 0.90 | 0.90 | 0.53 | 0.95 | 16.58 | 0.31 | 3.87 |
| 17870711 | RIVERFRONT | LA | Caddo | 22017025300 | 602 | 1 | 0.69 | 0.55 | 0.60 | 0.60 | 1.00 | 0.60 | 22.06 | 0.87 | 4.91 |
| 17871911 | SHREVEPORT (HOLLYWOOD YARD) | LA | Caddo | 22017023401 | 3009 | 0 | 0.69 | 0.55 | 0.60 | 0.60 | 0.56 | 0.62 | 20.20 | 0.69 | 4.32 |
| 17874811 | WEST LAKE | LA | Calcasieu | 22019002600 | 1846 | 0 | 0.40 | 0.69 | 0.73 | 0.73 | 0.56 | 0.02 | 20.30 | 0.71 | 3.83 |
| 18700611 | MONROE (KCS) | LA | Ouachita | 22073000700 | 1869 | 0 | 0.88 | 0.49 | 0.55 | 0.55 | 0.02 | 0.67 | 19.84 | 0.66 | 3.82 |
| 18701611 | BATON ROUGE (KCS) | LA | East Baton Rouge | 22033005100 | 1405 | 0 | 0.89 | 0.74 | 0.76 | 0.76 | 0.58 | 0.51 | 20.62 | 0.74 | 4.99 |
| 18701711 | LAKE CHARLES | LA | Calcasieu | 22019001500 | 1245 | 1 | 0.64 | 0.88 | 0.87 | 0.87 | 0.89 | 0.54 | 22.82 | 0.92 | 5.61 |
| 19467011 | HUB | LA | Allen | 22003950501 | 47 | 0 | 0.31 | 0.29 | 0.42 | 0.42 | 0.45 | 0.02 | 16.67 | 0.31 | 2.23 |
| 19467111 | OPELOUSAS | LA | St. Landry | 22097961401 | 2071 | 1 | 0.73 | 0.29 | 0.42 | 0.42 | 1.00 | 0.62 | 21.19 | 0.79 | 4.26 |
| 19662811 | LIVE OAK | LA | Jefferson | 22051027502 | 652 | 1 | 0.18 | 0.29 | 0.42 | 0.42 | 0.94 | 0.60 | 21.19 | 0.79 | 3.63 |
| 19735611 | AVONDALE | LA | Jefferson | 22051027601 | 464 | 0 | 0.40 | 0.88 | 0.87 | 0.87 | 0.65 | 0.28 | 19.58 | 0.64 | 4.58 |
| 19735711 | BRIMSTONE | LA | Calcasieu | 22019002701 | 86 | 0 | 0.47 | 0.29 | 0.42 | 0.42 | 0.60 | 0.25 | 18.46 | 0.51 | 2.96 |
| 19745811 | LOCKMOOR | LA | Calcasieu | 22019002702 | 157 | 0 | 0.18 | 0.55 | 0.60 | 0.60 | 0.60 | 0.25 | 18.46 | 0.51 | 3.30 |
| 14436311 | WEST SPRINGFIELD | MA | Hampden | 25013812300 | 2989 | 1 | 0.95 | 0.75 | 0.78 | 0.78 | 0.31 | 0.63 | 19.69 | 0.65 | 4.84 |
| 18314511 | FRAMINGHAM | MA | Middlesex | 25017383300 | 2175 | 0 | 0.53 | 0.42 | 0.52 | 0.52 | 0.50 | 0.15 | 15.39 | 0.20 | 2.84 |
| 14435411 | CUMBERLAND | MD | Allegany | 24001000200 | 83 | 0 | 0.40 | 0.83 | 0.83 | 0.83 | 0.33 | 0.78 | 15.86 | 0.23 | 4.24 |
| 14435511 | BAYVIEW (NS) | MD | Baltimore | 24005452300 | 3298 | 1 | 0.84 | 0.66 | 0.70 | 0.70 | 0.69 | 0.45 | 23.30 | 0.94 | 4.98 |
| 14435611 | BRUNSWICK | MD | Frederick | 24021775400 | 1594 | 0 | 0.31 | 0.67 | 0.71 | 0.71 | 0.31 | 0.17 | 15.90 | 0.24 | 3.11 |
| 14435711 | JESSUP | MD | Howard | 24027606901 | 1306 | 0 | 0.24 | 0.42 | 0.52 | 0.52 | 0.10 | 0.89 | 17.27 | 0.36 | 3.05 |
| 14435811 | HAGERSTOWN | MD | Washing-ton | 24043000900 | 1474 | 0 | 0.78 | 0.67 | 0.71 | 0.71 | 0.24 | 0.58 | 17.82 | 0.42 | 4.10 |
| 14436011 | CURTIS BAY | MD | Baltimore city | 24510250500 | 1178 | 1 | 0.64 | 0.75 | 0.78 | 0.78 | 0.50 | 0.65 | 22.89 | 0.93 | 5.02 |
| 14436111 | PENN MARY | MD | Baltimore city | 24510260605 | 1173 | 1 | 0.64 | 0.94 | 0.29 | 0.29 | 0.92 | 0.60 | 22.83 | 0.92 | 4.61 |
| 18794711 | VARDO YARD (NS) | MD | Washing-ton | 24043001001 | 1940 | 0 | 0.69 | 0.44 | 0.53 | 0.53 | 0.52 | 0.41 | 18.32 | 0.48 | 3.59 |
| 14436611 | BATTLE CREEK | MI | Calhoun | 26025002200 | 138 | 0 | 0.47 | 0.63 | 0.67 | 0.67 | 0.52 | 0.30 | 15.15 | 0.18 | 3.45 |
| 14436711 | GLADSTONE | MI | Delta | 26041970600 | 1464 | 0 | 0.31 | 0.37 | 0.48 | 0.48 | 0.87 | 0.36 | 12.69 | 0.04 | 2.92 |
| 14436811 | MCGREW | MI | Genesee | 26049012202 | 631 | 0 | 0.24 | 0.94 | 0.29 | 0.29 | 0.97 | 0.65 | 17.58 | 0.39 | 3.78 |
| 14436911 | JACKSON | MI | Jackson | 26075001200 | 977 | 0 | 0.53 | 0.75 | 0.78 | 0.78 | 0.60 | 0.60 | 18.69 | 0.54 | 4.59 |
| 14437511 | EAST PLYMOUTH | MI | Wayne | 26163561600 | 1665 | 0 | 0.64 | 0.94 | 0.29 | 0.29 | 0.56 | 0.06 | 18.21 | 0.47 | 3.25 |
| 14437611 | FLAT ROCK | MI | Wayne | 26163599001 | 1495 | 0 | 0.88 | 0.86 | 0.85 | 0.85 | 0.40 | 0.48 | 18.43 | 0.50 | 4.84 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{2.5}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14437711 | FORD | MI | Wayne | 26163558301 | 393 | 1 | 0.64 | 0.94 | 0.29 | 0.29 | 0.65 | 0.36 | 20.53 | 0.73 | 3.90 |
| 14437811 | LIVERNOIS | MI | Wayne | 26163984200 | 0 | 1 | 0.96 | 0.61 | 0.66 | 0.66 | 0.63 | 0.58 | 24.06 | 0.97 | 5.06 |
| 14437911 | OAKWOOD | MI | Wayne | 26163578600 | 3666 | 1 | 0.73 | 0.46 | 0.97 | 0.97 | 0.77 | 0.61 | 22.91 | 0.93 | 5.45 |
| 14438011 | ROUGEMERE | MI | Wayne | 26163573501 | 3942 | 1 | 0.84 | 0.94 | 0.29 | 0.29 | 0.92 | 0.67 | 22.66 | 0.91 | 4.87 |
| 14483211 | NORTH YARD (PLYMOUTH) | MI | Wayne | 26163561700 | 561 | 0 | 0.73 | 0.94 | 0.29 | 0.29 | 0.29 | 0.33 | 17.86 | 0.42 | 3.29 |
| 14483311 | TUNNEL YARD (SARNIA) | MI | St. Clair | 26147636000 | 623 | 1 | 0.64 | 0.37 | 0.48 | 0.48 | 0.60 | 0.58 | 19.68 | 0.65 | 3.82 |
| 14483411 | WAYNE | MI | Wayne | 26163566700 | 1846 | 1 | 0.73 | 0.94 | 0.29 | 0.29 | 0.63 | 0.59 | 20.24 | 0.69 | 4.16 |
| 18341111 | WAYNE (NS) | MI | Wayne | 26163566700 | 1846 | 1 | 0.69 | 0.21 | 0.35 | 0.35 | 0.63 | 0.59 | 20.24 | 0.69 | 3.53 |
| 14424211 | PROCTOR YARD | MN | St. Louis | 27137010200 | 86 | 0 | 0.47 | 0.63 | 0.67 | 0.67 | 0.35 | 0.77 | 12.53 | 0.04 | 3.60 |
| 14438411 | DILWORTH | MN | Clay | 27027030112 | 728 | 0 | 0.31 | 0.37 | 0.94 | 0.94 | 0.20 | 0.83 | 11.30 | 0.02 | 3.61 |
| 14438811 | WILLMAR | MN | Kandiyohi | 27067780500 | 474 | 0 | 0.82 | 0.41 | 0.50 | 0.50 | 0.48 | 0.39 | 16.60 | 0.31 | 3.40 |
| 14439211 | WINONA | MN | Winona | 27169670200 | 425 | 0 | 0.69 | 0.77 | 0.23 | 0.23 | 0.38 | 0.95 | 15.03 | 0.17 | 3.41 |
| 14483511 | NORTHTOWN | MN | Hennepin | 27053100500 | 1565 | 1 | 0.94 | 0.85 | 0.87 | 0.87 | 0.20 | 0.92 | 18.42 | 0.50 | 5.15 |
| 15528111 | PIGS EYE | MN | Ramsey | 27123980000 | 0 | 0 | 0.59 | 0.72 | 0.75 | 0.75 | NA | NA | 5.07 | 0.01 | NA |
| 16000311 | METRO TRANSIT - NORTH STAR MAINTENANCE | MN | Sherburne | 27141030410 | 300 | 0 | 0.59 | 0.71 | 0.21 | 0.21 | 0.15 | 0.78 | 14.82 | 0.15 | 2.81 |
| 17860311 | ALBERT LEA | MN | Freeborn | 27047180600 | 568 | 1 | 0.69 | 0.55 | 0.60 | 0.60 | 0.85 | 0.20 | 17.47 | 0.38 | 3.88 |
| 17861511 | BLUE EARTH | MN | Faribault | 27043460400 | 435 | 0 | 0.40 | 0.29 | 0.42 | 0.42 | 0.89 | 0.86 | 14.65 | 0.14 | 3.42 |
| 17863611 | EAST MINNEAPOLIS | MN | Hennepin | 27053104001 | 4040 | 1 | 0.96 | 0.69 | 0.73 | 0.73 | 0.05 | 0.36 | 20.79 | 0.75 | 4.26 |
| 17868211 | MANKATO | MN | Blue Earth | 27013170300 | 909 | 0 | 0.89 | 0.80 | 0.80 | 0.80 | 0.29 | 0.06 | 15.01 | 0.17 | 3.81 |
| 17872511 | SOUTH ST PAUL | MN | Dakota | 27037060202 | 3122 | 0 | 0.84 | 0.36 | 0.93 | 0.93 | 0.43 | 0.89 | 16.28 | 0.27 | 4.66 |
| 17872611 | ST JAMES | MN | Watonwan | 27165950200 | 641 | 1 | 0.40 | 0.69 | 0.73 | 0.73 | 0.83 | 0.98 | 17.32 | 0.37 | 4.72 |
| 17876111 | ROSEPORT | MN | Dakota | 27037061003 | 94 | 0 | 0.53 | 0.21 | 0.90 | 0.90 | 0.16 | 0.72 | 11.77 | 0.02 | 3.44 |
| 18305011 | GLENWOOD | MN | Pope | 27121970400 | 176 | 0 | 0.24 | 0.77 | 0.23 | 0.23 | 0.74 | 0.78 | 13.12 | 0.05 | 3.05 |
| 18305111 | HASTINGS | MN | Dakota | 27037061109 | 774 | 0 | 0.64 | 0.77 | 0.23 | 0.23 | 0.18 | 0.86 | 13.15 | 0.06 | 2.97 |
| 18306111 | WASECA | MN | Waseca | 27161790500 | 519 | 1 | 0.73 | 0.20 | 0.35 | 0.35 | 0.38 | 0.45 | 16.98 | 0.34 | 2.80 |
| 18306311 | THIEF RIVER FALLS | MN | Penning-ton | 27113090200 | 638 | 0 | 0.40 | 0.77 | 0.23 | 0.23 | 0.29 | 0.95 | 12.23 | 0.03 | 2.89 |
| 18341311 | WINONA (UP) | MN | Winona | 27169670400 | 1490 | 0 | 0.69 | 0.55 | 0.60 | 0.60 | 0.21 | 0.06 | 15.54 | 0.22 | 2.94 |
| 19467211 | JCT SWITCH | MN | Dakota | 27037060503 | 3293 | 0 | 0.78 | 0.29 | 0.42 | 0.42 | 0.25 | 0.02 | 15.31 | 0.19 | 2.38 |
| 19467311 | KASOTA | MN | Le Sueur | 27079950600 | 54 | 0 | 0.31 | 0.29 | 0.42 | 0.42 | 0.35 | 0.81 | 12.79 | 0.04 | 2.65 |
| 19467611 | WELCOME | MN | Martin | 27091790200 | 14 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.58 | 0.86 | 16.33 | 0.28 | 3.55 |
| 19467711 | VALLEY PARK | MN | Scott | 27139080304 | 1150 | 0 | 0.24 | 0.80 | 0.80 | 0.80 | 0.07 | 0.81 | 13.06 | 0.05 | 3.56 |
| 19745911 | ELK CREEK | MN | Nobles | 27105105100 | 9 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.50 | 0.78 | 13.24 | 0.06 | 3.18 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{2.5}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14456811 | ST. JOSEPH | MO | Buchanan | 29021003001 | 867 | 1 | 0.53 | 0.80 | 0.80 | 0.80 | 0.77 | 0.51 | 19.28 | 0.61 | 4.82 |
| 14456911 | POPLAR BLUFF | MO | Butler | 29023950700 | 907 | 1 | 0.31 | 0.84 | 0.84 | 0.84 | 0.98 | 0.60 | 21.34 | 0.80 | 5.21 |
| 14457011 | MURRAY | MO | Clay | 29047022100 | 764 | 1 | 0.24 | 0.47 | 0.98 | 0.98 | 0.53 | 0.95 | 19.92 | 0.66 | 4.80 |
| 14457111 | SPRINGFIELD | MO | Greene | 29077003300 | 1802 | 1 | 0.80 | 0.43 | 0.96 | 0.96 | 0.82 | 0.54 | 20.81 | 0.75 | 5.27 |
| 14457911 | SLATER | MO | Saline | 29195090100 | 28 | 0 | 0.24 | 0.98 | 0.34 | 0.34 | 0.98 | 0.17 | 18.43 | 0.50 | 3.55 |
| 14458111 | LINDENWOOD | MO | St. Louis city | 29510126800 | 3148 | 0 | 0.89 | 1.00 | 0.90 | 0.90 | 0.13 | 0.81 | 15.32 | 0.20 | 4.81 |
| 14483811 | BLUE RIVER | MO | Jackson | 29095015500 | 129 | 1 | 0.76 | 0.75 | 0.78 | 0.78 | 0.88 | 0.33 | 23.68 | 0.96 | 5.23 |
| 14483911 | KNOCHE | MO | Jackson | 29095015500 | 129 | 1 | 0.59 | 0.76 | 0.78 | 0.78 | 0.88 | 0.33 | 23.68 | 0.96 | 5.08 |
| 14484011 | LUTHER | MO | St. Louis city | 29510127000 | 208 | 1 | 0.47 | 0.60 | 0.66 | 0.66 | 0.21 | 0.55 | 22.35 | 0.89 | 4.03 |
| 17866211 | JEFFERSON CITY | MO | Cole | 29051020700 | 1296 | 1 | 0.78 | 0.29 | 0.42 | 0.42 | 0.38 | 0.50 | 19.02 | 0.58 | 3.36 |
| 17866611 | NEFF YARD | MO | Jackson | 29095015500 | 129 | 1 | 0.59 | 0.22 | 0.92 | 0.92 | 0.88 | 0.33 | 23.68 | 0.96 | 4.81 |
| 17867311 | LEES SUMMIT | MO | Jackson | 29095013804 | 866 | 0 | 0.69 | 0.29 | 0.42 | 0.42 | 0.14 | 0.81 | 12.06 | 0.02 | 2.79 |
| 17867411 | LESPERANCE | MO | St. Louis city | 29510127600 | 2347 | 0 | 0.88 | 0.21 | 0.90 | 0.90 | 0.09 | 0.77 | 15.30 | 0.19 | 3.93 |
| 17872811 | STE GENEVIEVE | MO | Ste. Genevieve | 29186960200 | 295 | 0 | 0.31 | 0.55 | 0.60 | 0.60 | 0.87 | 0.89 | 15.87 | 0.24 | 4.07 |
| 18309011 | VOLTZ | MO | Clay | 29047022200 | 232 | 0 | 0.07 | 0.85 | 0.85 | 0.85 | 0.22 | 0.83 | 15.61 | 0.22 | 3.89 |
| 18309411 | WENTZVILLE | MO | St. Charles | 29183312095 | 439 | 0 | 0.24 | 0.78 | 0.24 | 0.24 | 0.14 | 0.81 | 13.37 | 0.06 | 2.50 |
| 18341511 | MEXICO | MO | Audrain | 29007950700 | 315 | 0 | 0.59 | 0.76 | 0.22 | 0.22 | 0.74 | 0.11 | 15.14 | 0.18 | 2.82 |
| 19467411 | CAPEDEAU JCT | MO | Scott | 29201781100 | 108 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.60 | 0.95 | 17.98 | 0.44 | 3.82 |
| 19467811 | DESOTO | MO | Jefferson | 29099701300 | 271 | 0 | 0.40 | 0.55 | 0.60 | 0.60 | 0.69 | 0.17 | 15.07 | 0.17 | 3.20 |
| 14439511 | HATTIESBURG | MS | Forrest | 28035010700 | 955 | 1 | 0.47 | 0.18 | 0.18 | 0.18 | 0.76 | 0.56 | 19.86 | 0.66 | 2.99 |
| 14439611 | NORTH GULFPORT | MS | Harrison | 28047001800 | 695 | 1 | 0.31 | 0.71 | 0.75 | 0.75 | 0.97 | 0.62 | 22.16 | 0.88 | 4.99 |
| 14439911 | MERIDIAN (NS) | MS | Lauder-dale | 28075000600 | 1060 | 1 | 0.47 | 0.99 | 0.34 | 0.34 | 0.97 | 0.67 | 21.68 | 0.85 | 4.63 |
| 14440011 | FERGUSON | MS | Lawrence | 28077960100 | 23 | 0 | 0.07 | 0.73 | 0.76 | 0.76 | 0.81 | 0.25 | 18.16 | 0.45 | 3.81 |
| 14440311 | ARTESIA | MS | Lowndes | 28087001000 | 16 | 0 | 0.07 | 0.21 | 0.91 | 0.91 | 0.66 | 0.98 | 16.76 | 0.32 | 4.07 |
| 14484311 | NORTH JACKSON | MS | Hinds | 28049001100 | 1484 | 1 | 0.76 | 0.86 | 0.85 | 0.85 | 0.04 | 0.64 | 20.83 | 0.75 | 4.76 |
| 14484411 | PASCAGOULA (BAYOU CASSOTTE) | MS | Jackson | 28059042000 | 2602 | 1 | 0.53 | 0.94 | 0.29 | 0.29 | 0.38 | 0.36 | 19.52 | 0.63 | 3.42 |
| 14484511 | SOUTH YARD (MCCOMB) | MS | Pike | 28113950502 | 93 | 0 | 0.07 | 0.63 | 0.67 | 0.67 | 0.83 | 0.45 | 17.90 | 0.43 | 3.74 |
| 18700111 | JACKSON (HIGH OAK) | MS | Rankin | 28121020402 | 262 | 0 | 0.07 | 0.63 | 0.68 | 0.68 | 0.40 | 0.98 | 17.83 | 0.42 | 3.86 |
| 7398811 | QUALA SERVICES | MT | Custer | 30017961500 | 786 | 0 | 0.53 | 0.45 | 0.21 | 0.21 | 0.63 | 0.36 | 14.08 | 0.09 | 2.47 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14442411 | LAUREL | MT | Yellow-stone | 30111001902 | 943 | 0 | 0.31 | 0.72 | 0.75 | 0.75 | 0.24 | 0.11 | 13.37 | 0.06 | 2.95 |
| 14458311 | DILLON | MT | Beaver-head | 30001000300 | 435 | 0 | 0.31 | 0.29 | 0.42 | 0.42 | 0.50 | 0.28 | 14.13 | 0.09 | 2.32 |
| 14458711 | WARREN | MT | Carbon | 30009000500 | 1 | 1 | 0.07 | 0.39 | 0.49 | 0.49 | 0.72 | 0.95 | 15.40 | 0.20 | 3.30 |
| 14458811 | GREAT FALLS | MT | Cascade | 30013001600 | 2027 | 1 | 0.53 | 1.00 | 0.90 | 0.90 | 0.65 | 0.47 | 16.20 | 0.26 | 4.71 |
| 14458911 | GLENDIVE | MT | Dawson | 30021000300 | 131 | 0 | 0.40 | 0.73 | 0.76 | 0.76 | 0.50 | 0.95 | 12.69 | 0.04 | 4.14 |
| 14446711 | DAVIS | NC | Brunswick | 37019020108 | 485 | 1 | 0.24 | 0.82 | 0.82 | 0.82 | 0.53 | 0.25 | 20.54 | 0.73 | 4.21 |
| 14446811 | ASHEVILLE | NC | Buncombe | 37021000900 | 1916 | 1 | 0.76 | 0.98 | 0.33 | 0.33 | 0.93 | 0.53 | 18.95 | 0.57 | 4.42 |
| 14447011 | MILAN | NC | Cumber-land | 37051003800 | 623 | 1 | 0.73 | 0.94 | 0.29 | 0.29 | 0.92 | 0.59 | 21.07 | 0.77 | 4.53 |
| 14447211 | LINWOOD (SPENCER) | NC | Davidson | 37057061807 | 126 | 0 | 0.07 | 0.43 | 0.97 | 0.97 | 0.65 | 0.02 | 14.25 | 0.11 | 3.21 |
| 14447311 | ROCKY MOUNT | NC | Edge-combe | 37065020200 | 564 | 1 | 0.31 | 0.82 | 0.82 | 0.82 | 0.97 | 0.62 | 21.11 | 0.78 | 5.14 |
| 14447511 | HIGH POINT | NC | Guilford | 37081014300 | 1593 | 1 | 0.59 | 0.65 | 0.69 | 0.69 | 0.85 | 0.53 | 20.56 | 0.74 | 4.73 |
| 14447611 | PONOMA | NC | Guilford | 37081011602 | 2585 | 0 | 0.69 | 0.78 | 0.79 | 0.79 | 0.35 | 0.20 | 18.46 | 0.51 | 4.12 |
| 14447711 | CHARLOTTE | NC | Mecklen-burg | 37119005200 | 1723 | 1 | 0.89 | 0.89 | 0.88 | 0.88 | 0.74 | 0.61 | 20.89 | 0.76 | 5.66 |
| 14447811 | PINOCA | NC | Mecklen-burg | 37119004302 | 4133 | 1 | 0.40 | 0.82 | 0.82 | 0.82 | 0.58 | 0.50 | 20.93 | 0.76 | 4.69 |
| 14448011 | HAMLET | NC | Richmond | 37153971100 | 63 | 1 | 0.18 | 0.20 | 0.90 | 0.90 | 0.93 | 0.53 | 19.41 | 0.62 | 4.25 |
| 14448311 | BOSTIC | NC | Rutherford | 37161960103 | 80 | 0 | 0.18 | 0.94 | 0.29 | 0.29 | 0.91 | 0.15 | 17.18 | 0.36 | 3.11 |
| 14448411 | MONROE | NC | Union | 37179020406 | 2026 | 1 | 0.53 | 0.42 | 0.52 | 0.52 | 0.48 | 0.36 | 19.57 | 0.64 | 3.46 |
| 14448511 | RALEIGH | NC | Wake | 37183050400 | 2346 | 0 | 0.93 | 0.94 | 0.29 | 0.29 | 0.08 | 0.11 | 14.27 | 0.11 | 2.75 |
| 14484811 | NORTH WINSTON | NC | Forsyth | 37067001500 | 1503 | 0 | 0.76 | 0.72 | 0.75 | 0.75 | 0.58 | 0.48 | 18.33 | 0.48 | 4.52 |
| 18310011 | EAST DURHAM | NC | Durham | 37063002035 | 1762 | 0 | 0.64 | 0.64 | 0.69 | 0.69 | 0.07 | 0.11 | 16.74 | 0.32 | 3.16 |
| 18310211 | GLENWOOD | NC | Wake | 37183050400 | 2346 | 0 | 0.89 | 0.82 | 0.24 | 0.24 | 0.08 | 0.11 | 14.27 | 0.11 | 2.50 |
| 18341611 | CHARLOTTE REGIONAL INTERMODAL | NC | Mecklen-burg | 37119980100 | 0 | 0 | 0.18 | 0.86 | 0.25 | 0.25 | NA | NA | 4.05 | 0.00 | NA |
| 18341711 | OYAMA | NC | Catawba | 37035011000 | 372 | 1 | 0.24 | 0.40 | 0.49 | 0.49 | 0.98 | 0.46 | 21.38 | 0.80 | 3.88 |
| 14448811 | MANDAN | ND | Morton | 38059020303 | 130 | 0 | 0.78 | 0.66 | 0.69 | 0.69 | 0.22 | 0.77 | 12.20 | 0.03 | 3.85 |
| 14449311 | MINOT | ND | Ward | 38101010200 | 690 | 0 | 0.59 | 0.81 | 0.81 | 0.81 | 0.29 | 0.77 | 13.72 | 0.07 | 4.16 |
| 14449411 | HARVEY | ND | Wells | 38103959800 | 330 | 0 | 0.24 | 0.20 | 0.35 | 0.35 | 0.97 | 0.74 | 12.30 | 0.03 | 2.89 |
| 18304811 | NEW TOWN | ND | Mountrail | 38061940400 | 17 | 0 | 0.18 | 0.77 | 0.23 | 0.23 | 0.43 | 0.28 | 15.93 | 0.24 | 2.35 |
| 18304911 | ENDERLIN | ND | Ransom | 38073968900 | 6 | 0 | 0.24 | 0.77 | 0.23 | 0.23 | 0.82 | 0.74 | 14.02 | 0.09 | 3.12 |
| 18312911 | GRAND FORKS | ND | Grand Forks | 38035010700 | 3761 | 0 | 0.86 | 0.89 | 0.88 | 0.88 | 0.35 | 0.11 | 14.14 | 0.09 | 4.07 |
| 18313311 | FARGO | ND | Cass | 38017000700 | 4998 | 1 | 0.92 | 0.47 | 0.53 | 0.53 | 0.48 | 0.89 | 16.64 | 0.31 | 4.14 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14442611 | ALLIANCE | NE | Box Butte | 31013951300 | 55 | 0 | 0.47 | 0.48 | 0.98 | 0.98 | 0.48 | 0.75 | 13.45 | 0.07 | 4.21 |
| 14442711 | FREMONT (UP) | NE | Dodge | 31053964200 | 4268 | 1 | 0.80 | 0.29 | 0.42 | 0.42 | 0.18 | 0.78 | 17.43 | 0.37 | 3.27 |
| 14442911 | GRAND ISLAND | NE | Hall | 31079001000 | 951 | 0 | 0.53 | 0.55 | 0.60 | 0.60 | 0.31 | 0.74 | 15.66 | 0.23 | 3.57 |
| 14443111 | HOBSON | NE | Lancaster | 31109003402 | 2768 | 0 | 0.31 | 0.61 | 0.99 | 0.99 | 0.10 | 0.81 | 14.95 | 0.16 | 3.97 |
| 14443411 | BAILEY | NE | Lincoln | 31111959800 | 8 | 0 | 0.18 | 0.44 | 0.97 | 0.97 | 0.45 | 0.70 | 13.05 | 0.05 | 3.77 |
| 14443511 | MCCOOK | NE | Red Willow | 31145963300 | 134 | 0 | 0.53 | 0.73 | 0.76 | 0.76 | 0.53 | 0.74 | 15.53 | 0.21 | 4.27 |
| 14485011 | COLUMBUS | NE | Platte | 31141965700 | 951 | 0 | 0.69 | 0.29 | 0.42 | 0.42 | 0.45 | 0.72 | 15.47 | 0.21 | 3.20 |
| 17864611 | FALLS CITY | NE | Richard-son | 31147968600 | 98 | 1 | 0.40 | 0.69 | 0.73 | 0.73 | 0.89 | 0.77 | 17.01 | 0.35 | 4.55 |
| 17867511 | LEVEL | NE | Adams | 31001966200 | 7 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.43 | 0.69 | 14.25 | 0.10 | 3.06 |
| 17867611 | LEXINGTON | NE | Dawson | 31047968400 | 417 | 0 | 0.64 | 0.29 | 0.42 | 0.42 | 0.40 | 0.81 | 16.48 | 0.29 | 3.28 |
| 17872211 | SOUTH MORRILL | NE | Scotts Bluff | 31157953100 | 19 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.65 | 0.75 | 16.28 | 0.27 | 2.87 |
| 17873511 | OMAHA (UP) | NE | Douglas | 31055001800 | 5835 | 0 | 0.64 | 0.55 | 0.60 | 0.60 | 0.05 | 0.68 | 18.38 | 0.49 | 3.63 |
| 17873811 | VALLEY | NE | Douglas | 31055007504 | 80 | 0 | 0.40 | 0.69 | 0.73 | 0.73 | 0.45 | 0.74 | 16.27 | 0.27 | 4.01 |
| 19467911 | GOTHENBURG | NE | Dawson | 31047968200 | 155 | 0 | 0.31 | 0.69 | 0.73 | 0.73 | 0.65 | 0.72 | 13.83 | 0.08 | 3.90 |
| 19468011 | THUMEL | NE | Merrick | 31121966600 | 7 | 0 | 0.07 | 0.69 | 0.73 | 0.73 | 0.58 | 0.70 | 14.42 | 0.12 | 3.62 |
| 17776111 | ATLANTIC CITY | NJ | Atlantic | 34001001200 | 5761 | 1 | 0.76 | 0.18 | 0.18 | 0.18 | 0.79 | 0.59 | 21.02 | 0.77 | 3.46 |
| 17776211 | BURLINGTON | NJ | Burlington | 34005701103 | 1596 | 0 | 0.69 | 0.72 | 0.22 | 0.22 | 0.11 | 0.89 | 14.37 | 0.12 | 2.96 |
| 17776311 | PAVONIA | NJ | Camden | 34007600900 | 5030 | 1 | 0.96 | 0.89 | 0.88 | 0.88 | 0.45 | 0.64 | 22.45 | 0.90 | 5.60 |
| 17776411 | MILLVILLE | NJ | Cumber-land | 34011030402 | 292 | 1 | 0.64 | 0.85 | 0.24 | 0.24 | 0.58 | 0.25 | 19.51 | 0.63 | 3.44 |
| 17776511 | BRILLS | NJ | Essex | 34013007502 | 4683 | 1 | 0.86 | 0.86 | 0.24 | 0.24 | 0.29 | 0.39 | 23.15 | 0.94 | 3.81 |
| 17776611 | PAULSBORO | NJ | Gloucester | 34015500500 | 409 | 1 | 0.47 | 0.85 | 0.24 | 0.24 | 0.48 | 0.47 | 23.43 | 0.95 | 3.71 |
| 17776711 | BAYONNE | NJ | Hudson | 34017010800 | 1866 | 0 | 0.94 | 0.23 | 0.36 | 0.36 | 0.27 | 0.89 | 17.91 | 0.43 | 3.48 |
| 17776811 | BROWNS | NJ | Middlesex | 34023007801 | 550 | 0 | 0.59 | 0.74 | 0.77 | 0.77 | 0.12 | 0.78 | 13.83 | 0.08 | 3.85 |
| 17776911 | PORT MORRIS | NJ | Morris | 34027045402 | 1381 | 0 | 0.64 | 0.45 | 0.20 | 0.20 | 0.24 | 0.98 | 14.18 | 0.10 | 2.81 |
| 17777111 | EXPRESSRAIL ELIZABETH | NJ | Union | 34039980000 | 57 | 1 | 0.78 | 0.67 | 0.70 | 0.70 | 0.33 | 0.51 | 21.38 | 0.81 | 4.50 |
| 17777211 | RIDGEFIELD PARK | NJ | Bergen | 34003046300 | 11027 | 0 | 0.92 | 0.45 | 0.20 | 0.20 | 0.22 | 0.70 | 17.77 | 0.41 | 3.11 |
| 17777311 | WAVERLY | NJ | Essex | 34013980200 | 2 | 0 | 0.95 | 0.64 | 0.21 | 0.21 | 0.08 | 0.83 | 11.24 | 0.01 | 2.94 |
| 17777411 | GREENVILLE | NJ | Hudson | 34017005802 | 818 | 0 | 0.84 | 0.19 | 0.19 | 0.19 | 0.05 | 0.69 | 13.16 | 0.06 | 2.21 |
| 17777511 | METUCHEN | NJ | Middlesex | 34023001701 | 3623 | 0 | 0.78 | 0.72 | 0.22 | 0.22 | 0.18 | 0.73 | 14.79 | 0.15 | 3.00 |
| 17777611 | RARITAN | NJ | Somerset | 34035050600 | 2722 | 0 | 0.47 | 0.00 | 0.00 | 0.00 | 0.24 | 0.73 | 14.22 | 0.10 | 1.55 |
| 17777711 | ELIZABETH-PORT | NJ | Union | 34039980000 | 57 | 1 | 0.98 | 0.94 | 0.29 | 0.29 | 0.33 | 0.51 | 21.38 | 0.81 | 4.15 |
| 17777811 | HOBOKEN | NJ | Hudson | 34017012700 | 763 | 0 | 0.53 | 0.78 | 0.24 | 0.24 | 0.12 | 0.77 | 19.03 | 0.58 | 3.25 |
| 17777911 | PORT READING | NJ | Middlesex | 34023003401 | 1809 | 0 | 0.64 | 0.46 | 0.53 | 0.53 | 0.29 | 0.83 | 18.14 | 0.45 | 3.74 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17778011 | KEARNY (MEADOWS IMF) | NJ | Hudson | 34017007703 | 18503 | 0 | 1.00 | 0.75 | 0.77 | 0.77 | 0.00 | 0.68 | 15.58 | 0.22 | 4.19 |
| 17778111 | OAK ISLAND | NJ | Essex | 34013980200 | 2 | 0 | 0.80 | 0.86 | 0.85 | 0.85 | 0.08 | 0.83 | 11.24 | 0.01 | 4.29 |
| 17778211 | NORTH BERGEN | NJ | Hudson | 34017014600 | 1970 | 0 | 0.96 | 0.94 | 0.29 | 0.29 | 0.17 | 0.81 | 17.76 | 0.41 | 3.87 |
| 17778311 | PORT NEWARK | NJ | Essex | 34039980000 | 57 | 1 | 0.18 | 0.74 | 0.77 | 0.77 | 0.33 | 0.51 | 21.38 | 0.81 | 4.09 |
| 17778411 | LITTLE FERRY | NJ | Bergen | 34003045200 | 1368 | 0 | 0.93 | 0.94 | 0.29 | 0.29 | 0.38 | 0.69 | 18.05 | 0.44 | 3.97 |
| 17780111 | DOREMUS | NJ | Essex | 34013980200 | 2 | 0 | 0.59 | 0.88 | 0.25 | 0.25 | 0.08 | 0.83 | 11.24 | 0.01 | 2.91 |
| 17780211 | EXPRESSRAIL NEWARK | NJ | Essex | 34013980200 | 2 | 0 | 0.40 | 0.23 | 0.92 | 0.92 | 0.08 | 0.83 | 11.24 | 0.01 | 3.40 |
| 17780311 | SOUTH KEARNY | NJ | Hudson | 34017012700 | 763 | 0 | 0.64 | 0.99 | 0.35 | 0.35 | 0.12 | 0.77 | 19.03 | 0.58 | 3.79 |
| 18309611 | CROXTON | NJ | Hudson | 34017019900 | 2469 | 0 | 0.95 | 0.74 | 0.77 | 0.77 | 0.18 | 0.69 | 16.86 | 0.33 | 4.43 |
| 18312211 | NORTH BERGEN | NJ | Hudson | 34017014502 | 28649 | 0 | 0.97 | 0.74 | 0.77 | 0.77 | 0.03 | 0.43 | 17.76 | 0.41 | 4.12 |
| 18312311 | MORRIS | NJ | Morris | 34027045402 | 1381 | 0 | 0.64 | 0.64 | 0.21 | 0.21 | 0.24 | 0.98 | 14.18 | 0.10 | 3.01 |
| 18312411 | HOBOKEN | NJ | Hudson | 34017018301 | 5267 | 0 | 1.00 | 0.89 | 0.25 | 0.25 | 0.05 | 0.74 | 16.12 | 0.26 | 3.44 |
| 18341911 | GREENVILLE | NJ | Hudson | 34017005802 | 818 | 0 | 0.84 | 0.19 | 0.19 | 0.19 | 0.05 | 0.69 | 13.16 | 0.06 | 2.22 |
| 18342011 | MANVILLE | NJ | Somerset | 34035051400 | 3857 | 0 | 0.64 | 0.35 | 0.48 | 0.48 | 0.40 | 0.83 | 17.95 | 0.43 | 3.61 |
| 18342111 | RARITAN | NJ | Somerset | 34035050600 | 2722 | 0 | 0.47 | 0.18 | 0.18 | 0.18 | 0.24 | 0.73 | 14.22 | 0.10 | 2.09 |
| 18342211 | RIDGEFIELD PARK | NJ | Bergen | 34003046300 | 11027 | 0 | 0.92 | 0.45 | 0.20 | 0.20 | 0.22 | 0.70 | 17.77 | 0.41 | 3.10 |
| 18342311 | TRUMBULL | NJ | Union | 34039980000 | 57 | 1 | 0.98 | 0.99 | 0.35 | 0.35 | 0.33 | 0.51 | 21.38 | 0.81 | 4.31 |
| 14444911 | CLOVIS | NM | Curry | 35009000500 | 306 | 0 | 0.69 | 0.72 | 0.75 | 0.75 | 0.48 | 0.45 | 18.34 | 0.49 | 4.32 |
| 14445011 | GALLUP | NM | McKinley | 35031945201 | 199 | 0 | 0.69 | 0.83 | 0.83 | 0.83 | 0.40 | 0.60 | 15.46 | 0.21 | 4.38 |
| 14445111 | BELEN | NM | Valencia | 35061970901 | 575 | 1 | 0.59 | 0.22 | 0.91 | 0.91 | 0.77 | 0.43 | 19.33 | 0.61 | 4.44 |
| 17871511 | SANTA TERESA | NM | Dona Ana | 35013001701 | 14 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.24 | 0.25 | 16.95 | 0.34 | 2.03 |
| 19468511 | LORDSBURG | NM | Hidalgo | 35023970200 | 442 | 0 | 0.40 | 0.55 | 0.60 | 0.60 | 0.81 | 0.20 | 16.35 | 0.28 | 3.45 |
| 14444711 | SPARKS RAIL YARD | NV | Washoe | 32031003111 | 298 | 1 | 0.91 | 0.84 | 0.84 | 0.84 | 0.43 | 0.30 | 20.30 | 0.71 | 4.87 |
| 17864311 | ELKO | NV | Elko | 32007951401 | 38 | 0 | 0.18 | 0.55 | 0.60 | 0.60 | 0.20 | 0.11 | 12.15 | 0.03 | 2.27 |
| 17873611 | VALLEY | NV | Clark | 32003003649 | 233 | 0 | 0.31 | 0.55 | 0.60 | 0.60 | 0.07 | 0.06 | 14.66 | 0.14 | 2.35 |
| 19468111 | ARROLIME | NV | Clark | 32003005902 | 1 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.48 | 0.28 | 16.90 | 0.34 | 2.29 |
| 19468211 | VIVIAN HBD | NV | Elko | 32007951202 | 4 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.31 | 0.20 | 15.85 | 0.23 | 2.58 |
| 19468311 | RYE PATCH | NV | Pershing | 32027960100 | 1 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.48 | 0.86 | 17.50 | 0.39 | 3.56 |
| 19756011 | ARDEN | NV | Clark | 32003002983 | 3293 | 0 | 0.73 | 0.69 | 0.73 | 0.73 | 0.05 | 0.77 | 15.07 | 0.17 | 3.87 |
| 14445211 | SELKIRK | NY | Albany | 36001014304 | 211 | 0 | 0.07 | 0.39 | 0.95 | 0.95 | 0.22 | 0.25 | 11.53 | 0.02 | 2.85 |
| 14445411 | OLEAN | NY | Cattaraugus | 36009961100 | 69 | 0 | 0.40 | 0.00 | 0.00 | 0.00 | 0.66 | 0.43 | 14.96 | 0.16 | 1.65 |
| 14445511 | BISON | NY | Erie | 36029010901 | 1963 | 0 | 0.64 | 0.85 | 0.85 | 0.85 | 0.74 | 0.47 | 13.47 | 0.07 | 4.47 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14445711 | KENMORE | NY | Erie | 36029008400 | 427 | 0 | 0.59 | 0.42 | 0.52 | 0.52 | 0.65 | 0.53 | 16.75 | 0.32 | 3.54 |
| 14445911 | BUFFALO CREEK (BPRR) | NY | Erie | 36029000110 | 794 | 0 | 0.59 | 0.65 | 0.69 | 0.69 | 0.48 | 0.58 | 17.19 | 0.36 | 4.04 |
| 14446111 | NIAGARA | NY | Niagara | 36063020300 | 928 | 0 | 0.59 | 0.94 | 0.29 | 0.29 | 0.97 | 0.64 | 18.54 | 0.53 | 4.25 |
| 14446311 | DEWITT | NY | Onondaga | 36067015400 | 1120 | 0 | 0.47 | 0.75 | 0.78 | 0.78 | 0.48 | 0.36 | 15.27 | 0.19 | 3.79 |
| 14446511 | GANG MILLS | NY | Steuben | 36101962301 | 152 | 0 | 0.24 | 0.85 | 0.85 | 0.85 | 0.40 | 0.15 | 14.25 | 0.11 | 3.45 |
| 14446611 | OWEGO (OHRY) | NY | Tioga | 36107020500 | 1316 | 0 | 0.31 | 0.20 | 0.35 | 0.35 | 0.72 | 0.54 | 18.16 | 0.45 | 2.92 |
| 14485411 | FRONTIER | NY | Erie | 36029010700 | 1249 | 0 | 0.69 | 0.82 | 0.82 | 0.82 | 0.76 | 0.47 | 16.70 | 0.31 | 4.69 |
| 14485511 | SARATOGA SPRINGS | NY | Saratoga | 36091061305 | 770 | 0 | 0.31 | 0.88 | 0.25 | 0.25 | 0.27 | 0.20 | 14.66 | 0.14 | 2.30 |
| 18306211 | KENWOOD | NY | Albany | 36001002600 | 2891 | 1 | 0.69 | 0.46 | 0.20 | 0.20 | 0.40 | 0.66 | 20.27 | 0.70 | 3.32 |
| 18309811 | EAST BINGHAMTON | NY | Broome | 36007012701 | 202 | 0 | 0.40 | 0.74 | 0.77 | 0.77 | 0.53 | 0.51 | 19.72 | 0.66 | 4.37 |
| 18342411 | ELMIRA | NY | Chemung | 36015000100 | 1588 | 0 | 0.76 | 0.89 | 0.88 | 0.88 | 0.85 | 0.66 | 17.71 | 0.41 | 5.32 |
| 14426211 | SANDUSKY | OH | Erie | 39043041600 | 277 | 0 | 0.31 | 0.86 | 0.25 | 0.25 | 0.69 | 0.98 | 13.97 | 0.08 | 3.42 |
| 14449611 | LIMA | OH | Allen | 39003012400 | 3209 | 0 | 0.59 | 0.94 | 0.29 | 0.29 | 0.56 | 0.51 | 17.97 | 0.44 | 3.62 |
| 14450211 | CRESTLINE | OH | Crawford | 39033974900 | 363 | 0 | 0.40 | 0.46 | 0.53 | 0.53 | 0.89 | 0.39 | 14.57 | 0.13 | 3.32 |
| 14450411 | COLLINWOOD | OH | Cuyahoga | 39035980900 | 0 | 0 | 0.82 | 0.61 | 0.66 | 0.66 | 0.45 | 0.64 | 18.41 | 0.50 | 4.36 |
| 14450611 | ROCKPORT | OH | Cuyahoga | 39035124500 | 2617 | 1 | 0.82 | 1.00 | 0.90 | 0.90 | 0.79 | 0.43 | 20.68 | 0.74 | 5.57 |
| 14450711 | ANSONIA | OH | Darke | 39037520100 | 47 | 0 | 0.31 | 0.61 | 0.66 | 0.66 | 0.72 | 0.25 | 14.69 | 0.14 | 3.36 |
| 14450811 | BELLEVUE | OH | Erie | 39043041800 | 78 | 0 | 0.07 | 0.65 | 1.00 | 1.00 | 0.60 | 0.89 | 11.72 | 0.02 | 4.24 |
| 14451011 | PARSONS YARD | OH | Franklin | 39049008811 | 877 | 1 | 0.78 | 0.82 | 0.82 | 0.82 | 0.01 | 0.57 | 20.08 | 0.68 | 4.49 |
| 14451111 | GEST STREET | OH | Hamilton | 39061026300 | 530 | 1 | 0.92 | 0.47 | 0.53 | 0.53 | 0.77 | 0.67 | 21.58 | 0.82 | 4.73 |
| 14451211 | IVORYDALE | OH | Hamilton | 39061025800 | 2588 | 0 | 0.78 | 0.42 | 0.52 | 0.52 | 0.38 | 0.17 | 16.88 | 0.33 | 3.12 |
| 14451411 | WILLARD | OH | Huron | 39077916200 | 163 | 0 | 0.31 | 0.38 | 0.94 | 0.94 | 0.58 | 0.33 | 16.23 | 0.27 | 3.76 |
| 14451511 | MINGO JCT. | OH | Jefferson | 39081011900 | 105 | 0 | 0.40 | 0.74 | 0.77 | 0.77 | 0.95 | 0.39 | 17.84 | 0.42 | 4.44 |
| 14451811 | PORTSMOUTH | OH | Scioto | 39145003100 | 321 | 0 | 0.40 | 1.00 | 0.89 | 0.89 | 1.00 | 0.54 | 18.51 | 0.52 | 5.24 |
| 14452011 | LORDSTOWN (CSXT) | OH | Trumbull | 39155933400 | 144 | 0 | 0.24 | 0.42 | 0.52 | 0.52 | 0.83 | 0.17 | 16.11 | 0.26 | 2.95 |
| 14452111 | WALLBRIDGE | OH | Wood | 39173020800 | 474 | 0 | 0.31 | 0.42 | 0.52 | 0.52 | 0.87 | 0.25 | 16.01 | 0.25 | 3.13 |
| 14485611 | AIRLINE JCT. | OH | Lucas | 39095003500 | 1912 | 0 | 0.91 | 0.83 | 0.83 | 0.83 | 0.83 | 0.65 | 18.56 | 0.53 | 5.39 |
| 14486111 | QUEENSGATE | OH | Hamilton | 39061002800 | 990 | 1 | 0.92 | 0.22 | 0.91 | 0.91 | 0.27 | 0.50 | 20.06 | 0.68 | 4.40 |
| 14486211 | STANLEY | OH | Wood | 39173020800 | 474 | 0 | 0.07 | 0.35 | 0.93 | 0.93 | 0.87 | 0.25 | 16.01 | 0.25 | 3.64 |
| 18310411 | ASHTABULA HARBOR | OH | Ashtabula | 39007000400 | 937 | 0 | 0.07 | 0.19 | 0.19 | 0.19 | 0.03 | 0.47 | 18.48 | 0.52 | 1.65 |
| 18310911 | SOUTH LORAIN | OH | Lorain | 39093028100 | 382 | 0 | 0.64 | 0.64 | 0.21 | 0.21 | 0.53 | 0.95 | 14.53 | 0.12 | 3.30 |
| 18311211 | FOSTORIA MIXING CENTER | OH | Seneca | 39147962700 | 45 | 0 | 0.07 | 0.66 | 0.70 | 0.70 | 0.56 | 0.92 | 11.58 | 0.02 | 3.63 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18311311 | CANTON | OH | Stark | 39151712400 | 1003 | 0 | 0.40 | 0.87 | 0.86 | 0.86 | 0.81 | 0.17 | 17.05 | 0.35 | 4.31 |
| 18312011 | NORTH BALTIMORE | OH | Wood | 39173022300 | 37 | 0 | 0.07 | 0.67 | 0.71 | 0.71 | 0.58 | 0.20 | 14.17 | 0.10 | 3.04 |
| 18342511 | COLUMBUS (WATKINS RD) | OH | Franklin | 39049008812 | 1026 | 1 | 0.64 | 0.64 | 0.68 | 0.68 | 0.77 | 0.47 | 20.23 | 0.69 | 4.59 |
| 18342711 | FOSTORIA (BLAIR) | OH | Seneca | 39147963000 | 472 | 0 | 0.18 | 0.66 | 0.70 | 0.70 | 0.98 | 0.33 | 17.06 | 0.35 | 3.90 |
| 18342811 | LORDSTOWN | OH | Trumbull | 39155933400 | 144 | 0 | 0.24 | 0.44 | 0.52 | 0.52 | 0.83 | 0.17 | 16.11 | 0.26 | 2.98 |
| 14452211 | NORTH ENID | OK | Garfield | 40047000200 | 471 | 0 | 0.31 | 0.84 | 0.84 | 0.84 | 0.50 | 0.28 | 15.43 | 0.21 | 3.82 |
| 14452311 | HEAVENER | OK | Le Flore | 40079040601 | 20 | 0 | 0.24 | 0.38 | 0.49 | 0.49 | 0.83 | 0.53 | 18.07 | 0.45 | 3.39 |
| 14452511 | CHEROKEE | OK | Tulsa | 40143006600 | 248 | 0 | 0.47 | 0.89 | 0.91 | 0.91 | 0.72 | 0.39 | 18.55 | 0.53 | 4.82 |
| 15528511 | WATTS | OK | Adair | 40001376600 | 29 | 0 | 0.24 | 0.38 | 0.49 | 0.49 | 0.95 | 0.60 | 18.93 | 0.57 | 3.71 |
| 17868711 | MUSKOGEE | OK | Muskogee | 40101000700 | 2229 | 1 | 0.69 | 0.21 | 0.90 | 0.90 | 0.91 | 0.64 | 20.90 | 0.76 | 5.01 |
| 17869711 | OKLAHOMA CITY | OK | Oklahoma | 40109109500 | 1233 | 1 | 0.73 | 0.29 | 0.42 | 0.42 | 0.24 | 0.57 | 19.82 | 0.66 | 3.32 |
| 17870411 | PRYOR | OK | Mayes | 40097040400 | 45 | 0 | 0.07 | 0.69 | 0.73 | 0.73 | 0.83 | 0.57 | 18.67 | 0.54 | 4.15 |
| 17873411 | TULSA | OK | Tulsa | 40143009019 | 938 | 0 | 0.78 | 0.69 | 0.73 | 0.73 | 0.15 | 0.17 | 14.97 | 0.16 | 3.42 |
| 18343011 | ENID | OK | Garfield | 40047000701 | 4457 | 1 | 0.64 | 0.66 | 0.69 | 0.69 | 0.52 | 0.51 | 20.03 | 0.67 | 4.39 |
| 19468611 | EL RENO | OK | Canadian | 40017300400 | 992 | 1 | 0.53 | 0.55 | 0.60 | 0.60 | 0.88 | 0.65 | 20.33 | 0.71 | 4.53 |
| 14453211 | KLAMATH FALLS | OR | Klamath | 41035971700 | 2562 | 0 | 0.64 | 0.29 | 0.42 | 0.42 | 0.58 | 0.57 | 17.89 | 0.43 | 3.35 |
| 14453311 | EUGENE | OR | Lane | 41039004200 | 2206 | 1 | 0.78 | 0.80 | 0.80 | 0.80 | 0.29 | 0.61 | 22.20 | 0.88 | 4.96 |
| 14453811 | BARNES | OR | Mult-nomah | 41051004103 | 3487 | 1 | 0.59 | 0.84 | 0.84 | 0.84 | 0.13 | 0.51 | 21.16 | 0.78 | 4.53 |
| 14453911 | BROOKLYN | OR | Mult-nomah | 41051000202 | 7659 | 0 | 0.84 | 0.69 | 0.73 | 0.73 | 0.17 | 0.36 | 19.60 | 0.64 | 4.16 |
| 14486311 | ALBINA | OR | Mult-nomah | 41051980000 | 25 | 0 | 0.84 | 0.48 | 0.98 | 0.98 | NA | NA | 11.87 | 0.02 | NA |
| 17869811 | ONTARIO | OR | Malheur | 41045970500 | 78 | 0 | 0.18 | 0.55 | 0.60 | 0.60 | 0.74 | 0.45 | 16.17 | 0.26 | 3.39 |
| 17873011 | THE DALLES | OR | Wasco | 41065970100 | 912 | 0 | 0.40 | 0.55 | 0.60 | 0.60 | 0.77 | 0.20 | 16.76 | 0.32 | 3.46 |
| 18343111 | KLAMATH FALLS | OR | Klamath | 41035971500 | 636 | 1 | 0.47 | 0.89 | 0.88 | 0.88 | 0.97 | 0.59 | 19.70 | 0.65 | 5.34 |
| 18700411 | SALEM (OR) | OR | Marion | 41047001000 | 830 | 1 | 0.82 | 0.29 | 0.42 | 0.42 | 0.66 | 0.57 | 20.26 | 0.70 | 3.89 |
| 19468711 | RIVER GATE | OR | Mult-nomah | 41051007202 | 289 | 1 | 0.24 | 0.55 | 0.60 | 0.60 | 0.13 | 0.51 | 21.16 | 0.78 | 3.42 |
| 2985111 | EAGLE RAILCAR SVC/DUBOIS RAILCAR PLT | PA | Clearfield | 42033330200 | 3419 | 0 | 0.47 | 0.71 | 0.95 | 0.95 | 0.60 | 0.33 | 17.68 | 0.40 | 4.41 |
| 3854511 | NORFOLK SOUTHERN RAILWAY/ CONWAY | PA | Beaver | 42007603202 | 637 | 0 | 0.47 | 0.94 | 0.29 | 0.29 | 0.38 | 0.02 | 15.94 | 0.24 | 2.63 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{2.5}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4702611 | UTC RAILCAR REPAIR SVC LLC/SAYRE PLT | PA | Bradford | 42015950502 | 76 | 0 | 0.40 | NA | NA | NA | 0.74 | 0.20 | 17.06 | 0.35 | NA |
| 4730911 | UNION TANK CAR/ALTOONA SHOP | PA | Blair | 42013100700 | 4153 | 0 | 0.69 | 0.78 | 0.35 | 0.35 | 0.72 | 0.65 | 15.49 | 0.21 | 3.76 |
| 4731011 | CURRY RAIL SVC INC/ FRANKSTOWN | PA | Blair | 42013010900 | 150 | 0 | 0.40 | 0.45 | 0.20 | 0.20 | 0.60 | 0.06 | 13.51 | 0.07 | 1.98 |
| 6582611 | ACF IND LLC/ MILTON | PA | Northum-berland | 42097080301 | 1595 | 0 | 0.40 | 0.86 | 0.25 | 0.25 | 0.76 | 0.30 | 18.26 | 0.48 | 3.29 |
| 14454711 | CONWAY | PA | Beaver | 42007603600 | 1487 | 0 | 0.59 | 0.76 | 0.86 | 0.86 | 0.85 | 0.20 | 17.77 | 0.41 | 4.53 |
| 14454811 | ALTOONA | PA | Blair | 42013010701 | 683 | 0 | 0.59 | 0.50 | 0.55 | 0.55 | 0.33 | 0.39 | 15.98 | 0.25 | 3.15 |
| 14454911 | MORRISVILLE | PA | Bucks | 42017105801 | 1793 | 0 | 0.76 | 0.71 | 0.22 | 0.22 | 0.17 | 0.20 | 18.47 | 0.51 | 2.79 |
| 14455111 | ENOLA | PA | Cumber-land | 42041010100 | 2736 | 0 | 0.47 | 0.74 | 0.86 | 0.86 | 0.25 | 0.39 | 17.08 | 0.35 | 3.92 |
| 14455411 | HARRISBURG | PA | Dauphin | 42043021100 | 1220 | 1 | 0.53 | 0.36 | 0.94 | 0.94 | 0.66 | 0.66 | 21.52 | 0.82 | 4.91 |
| 14455511 | ERIE | PA | Erie | 42049001500 | 2940 | 0 | 0.76 | 0.94 | 0.29 | 0.29 | 0.85 | 0.67 | 19.55 | 0.63 | 4.43 |
| 14455611 | CONNELLS-VILLE | PA | Fayette | 42051260700 | 3400 | 0 | 0.47 | 0.42 | 0.52 | 0.52 | 0.63 | 0.43 | 17.19 | 0.36 | 3.34 |
| 14455711 | NEWCASTLE | PA | Lawrence | 42073011100 | 224 | 0 | 0.07 | 0.42 | 0.52 | 0.52 | 0.85 | 0.30 | 17.17 | 0.36 | 3.03 |
| 14455811 | ALLENTOWN | PA | Lehigh | 42077009601 | 3052 | 1 | 0.82 | 0.41 | 0.96 | 0.96 | 0.92 | 0.54 | 21.81 | 0.86 | 5.47 |
| 14486511 | ABRAMS | PA | Montgom-ery | 42091205808 | 2826 | 0 | 0.59 | 0.81 | 0.81 | 0.81 | 0.33 | 0.81 | 18.22 | 0.47 | 4.63 |
| 18311611 | PITCAIRN | PA | Allegheny | 42003521302 | 1471 | 0 | 0.47 | 0.40 | 0.50 | 0.50 | 0.43 | 0.06 | 17.73 | 0.41 | 2.76 |
| 18311811 | FRANKLIN COUNTY RIF | PA | Franklin | 42055011702 | 303 | 0 | 0.07 | 0.35 | 0.48 | 0.48 | 0.38 | 0.25 | 13.14 | 0.05 | 2.06 |
| 14456111 | BENNETT | SC | Charleston | 45019003800 | 3088 | 1 | 0.64 | 0.83 | 0.83 | 0.83 | 0.76 | 0.50 | 21.78 | 0.86 | 5.25 |
| 14456311 | FLORENCE | SC | Florence | 45041000800 | 1457 | 1 | 0.47 | 0.82 | 0.82 | 0.82 | 0.89 | 0.55 | 20.28 | 0.70 | 5.07 |
| 14456411 | CAYCE | SC | Lexington | 45063020100 | 602 | 0 | 0.47 | 0.75 | 0.78 | 0.78 | 0.29 | 0.92 | 15.76 | 0.23 | 4.20 |
| 14456511 | HAYNE | SC | Spartan-burg | 45083021700 | 1717 | 1 | 0.40 | 0.20 | 0.90 | 0.90 | 0.63 | 0.56 | 22.17 | 0.88 | 4.46 |
| 14486811 | ANDREWS-COLUMBIA | SC | Richland | 45079011701 | 386 | 0 | 0.47 | 0.85 | 0.85 | 0.85 | 0.05 | 0.63 | 18.45 | 0.51 | 4.20 |
| 14487011 | SEVEN MILE | SC | Charleston | 45019003300 | 2002 | 1 | 0.80 | 0.39 | 0.49 | 0.49 | 0.74 | 0.48 | 22.93 | 0.93 | 4.33 |
| 18314711 | GREENVILLE | SC | Greenville | 45045000900 | 3230 | 1 | 0.69 | 0.72 | 0.22 | 0.22 | 0.45 | 0.36 | 19.34 | 0.61 | 3.27 |
| 18700011 | MAXWELL | SC | Green-wood | 45047970402 | 324 | 0 | 0.31 | 0.61 | 0.66 | 0.66 | 0.53 | 0.74 | 17.60 | 0.40 | 3.93 |
| 18313111 | SIOUX FALLS | SD | Minneha-ha | 46099000500 | 3357 | 0 | 0.95 | 0.41 | 0.50 | 0.50 | 0.69 | 0.06 | 13.90 | 0.08 | 3.19 |
| 14459211 | CLEVELAND | TN | Bradley | 47011010700 | 1876 | 1 | 0.47 | 0.19 | 0.19 | 0.19 | 0.72 | 0.57 | 19.78 | 0.66 | 2.99 |
| 14459311 | BRUCETON | TN | Carroll | 47017962000 | 47 | 0 | 0.24 | 0.94 | 0.29 | 0.29 | 0.95 | 0.36 | 15.05 | 0.17 | 3.25 |
| 14459411 | TULLAHOMA | TN | Coffee | 47031970801 | 1264 | 0 | 0.59 | 0.94 | 0.29 | 0.29 | 0.77 | 0.25 | 16.75 | 0.32 | 3.45 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14459511 | KAYNE AVENUE | TN | Davidson | 47037019502 | 5859 | 0 | 0.94 | 0.94 | 0.29 | 0.29 | 0.07 | 0.75 | 16.91 | 0.34 | 3.63 |
| 14459711 | RADNOR | TN | Davidson | 47037980200 | 2 | 0 | 0.69 | 0.35 | 0.93 | 0.93 | NA | NA | 5.45 | 0.01 | NA |
| 14459811 | CSX TRANS-PORTATION, INC. (CRAVENS YARD) | TN | Hamilton | 47065002000 | 1640 | 1 | 0.53 | 0.94 | 0.29 | 0.29 | 0.27 | 0.30 | 19.36 | 0.61 | 3.24 |
| 14459911 | NORFOLK SOUTHERN RAILWAY COMPANY (DEBUTTS YARD, CHAT-TANOOGA) | TN | Hamilton | 47065012300 | 829 | 1 | 0.53 | 0.62 | 0.99 | 0.99 | 0.77 | 0.61 | 21.23 | 0.79 | 5.31 |
| 14460011 | CSX TRANS-PORTATION, INC. (WAU-HATCHIE YARD) | TN | Hamilton | 47065012100 | 225 | 0 | 0.18 | 0.94 | 0.29 | 0.29 | 0.76 | 0.28 | 18.40 | 0.50 | 3.24 |
| 14460111 | BULLS GAP (WARD YARD) | TN | Hawkins | 47073050900 | 110 | 1 | 0.18 | 0.19 | 0.19 | 0.19 | 0.94 | 0.43 | 19.51 | 0.62 | 2.73 |
| 14460211 | NEW JOHNSONVILLE | TN | Hum-phreys | 47085130500 | 64 | 0 | 0.18 | 0.94 | 0.29 | 0.29 | 0.79 | 0.20 | 14.57 | 0.13 | 2.82 |
| 14460311 | KNOXVILLE (SEVIER YARD) | TN | Knox | 47093005202 | 506 | 0 | 0.18 | 0.82 | 0.82 | 0.82 | 0.52 | 0.17 | 16.70 | 0.31 | 3.65 |
| 14460511 | WEST KNOXVILLE | TN | Knox | 47093000902 | 6391 | 0 | 0.69 | 0.42 | 0.52 | 0.52 | 0.00 | 0.63 | 15.41 | 0.20 | 2.98 |
| 14460711 | ETOWAH | TN | McMinn | 47107970700 | 132 | 0 | 0.24 | 0.94 | 0.29 | 0.29 | 0.94 | 0.43 | 18.83 | 0.55 | 3.68 |
| 14460811 | FULTON | TN | Obion | 47131965000 | 78 | 0 | 0.31 | 0.64 | 0.21 | 0.21 | 0.94 | 0.36 | 17.91 | 0.43 | 3.09 |
| 14460911 | EMORY GAP | TN | Roane | 47145030700 | 180 | 1 | 0.18 | 0.44 | 0.53 | 0.53 | 0.92 | 0.30 | 18.98 | 0.57 | 3.46 |
| 14461011 | MURFREES-BORO | TN | Rutherford | 47149041800 | 780 | 0 | 0.73 | 0.94 | 0.29 | 0.29 | 0.33 | 0.51 | 18.69 | 0.54 | 3.63 |
| 14461311 | MEMPHIS (HARRISON YARD) | TN | Shelby | 47157022220 | 1261 | 1 | 0.53 | 0.40 | 0.96 | 0.96 | 0.95 | 0.60 | 22.08 | 0.87 | 5.26 |
| 14461411 | LEEWOOD | TN | Shelby | 47157011100 | 942 | 1 | 0.86 | 0.94 | 0.29 | 0.29 | 0.03 | 0.66 | 22.21 | 0.88 | 3.96 |
| 14461711 | ERWIN | TN | Unicoi | 47171080200 | 245 | 0 | 0.40 | 0.94 | 0.29 | 0.29 | 1.00 | 0.36 | 17.94 | 0.43 | 3.71 |
| 14487111 | KINGSPORT | TN | Sullivan | 47163040200 | 652 | 1 | 0.40 | 0.94 | 0.29 | 0.29 | 0.02 | 0.61 | 21.51 | 0.82 | 3.37 |
| 19756111 | MEMPHIS | TN | Shelby | 47157006200 | 2667 | 1 | 0.95 | 0.44 | 0.97 | 0.97 | 0.93 | 0.60 | 20.12 | 0.68 | 5.53 |
| 14461911 | PALESTINE | TX | Anderson | 48001950700 | 987 | 1 | 0.47 | 0.29 | 0.42 | 0.42 | 0.65 | 0.43 | 21.45 | 0.81 | 3.48 |
| 14462111 | TEMPLE | TX | Bell | 48027020600 | 2488 | 0 | 0.53 | NA | NA | NA | 0.63 | 0.17 | 19.05 | 0.58 | NA |
| 14462211 | SAN ANTONIO EAST YARD | TX | Bexar | 48029130600 | 5822 | 1 | 0.98 | 0.99 | 0.89 | 0.89 | 0.85 | 0.56 | 25.29 | 0.98 | 6.14 |
| 14462411 | ANGLETON 1 | TX | Brazoria | 48039663100 | 183 | 0 | 0.47 | NA | NA | NA | 0.35 | 0.72 | 15.47 | 0.21 | NA |
| 14462711 | HARLINGEN | TX | Cameron | 48061010500 | 1551 | 0 | 0.92 | 0.09 | 0.09 | 0.09 | 0.82 | 0.95 | 20.93 | 0.76 | 3.72 |
| 14463211 | JAMA1 | TX | Comal | 48091310904 | 428 | 0 | 0.18 | NA | NA | NA | 0.24 | 0.78 | 15.04 | 0.17 | NA |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14463411 | BROWDER | TX | Dallas | 48113020500 | 2440 | 1 | 0.96 | 0.29 | 0.42 | 0.42 | 0.53 | 0.60 | 21.51 | 0.82 | 4.04 |
| 14463611 | ALFALFA | TX | El Paso | 48141003501 | 741 | 1 | 0.91 | 0.99 | 0.89 | 0.89 | 0.69 | 0.77 | 23.09 | 0.93 | 6.07 |
| 14463711 | GALVESTON | TX | Galveston | 48167724000 | 346 | 0 | 0.59 | 0.55 | 0.60 | 0.60 | 0.10 | 0.45 | 16.54 | 0.30 | 3.20 |
| 14464111 | SILSBEE | TX | Hardin | 48199030800 | 359 | 0 | 0.40 | 0.66 | 0.69 | 0.69 | 0.69 | 0.30 | 18.79 | 0.55 | 3.99 |
| 14464311 | BOOTH | TX | Harris | 48201311100 | 4879 | 1 | 0.88 | NA | NA | NA | 0.66 | 0.98 | 25.56 | 0.99 | NA |
| 14464611 | ENGLEWOOD | TX | Harris | 48201212400 | 937 | 1 | 0.89 | 0.47 | 0.98 | 0.98 | 0.63 | 0.06 | 26.07 | 1.00 | 5.02 |
| 14464911 | STRANG | TX | Harris | 48201343301 | 985 | 0 | 0.31 | 0.43 | 0.96 | 0.96 | 0.18 | 0.95 | 19.59 | 0.64 | 4.45 |
| 14465111 | BIG SPRING | TX | Howard | 48227950300 | 402 | 0 | 0.47 | 0.55 | 0.60 | 0.60 | 0.03 | 0.11 | 18.76 | 0.55 | 2.92 |
| 14465511 | CHAISON | TX | Jefferson | 48245011205 | 112 | 0 | 0.47 | 0.83 | 0.83 | 0.83 | 0.35 | 0.89 | 18.48 | 0.52 | 4.72 |
| 14465611 | GUFFEY | TX | Jefferson | 48245011205 | 112 | 0 | 0.24 | 0.29 | 0.42 | 0.42 | 0.20 | 0.70 | 18.61 | 0.54 | 2.81 |
| 14466411 | LUBBOCK | TX | Lubbock | 48303000700 | 1247 | 0 | 0.86 | 0.38 | 0.95 | 0.95 | 0.22 | 0.83 | 16.43 | 0.29 | 4.48 |
| 14466611 | EAGLE PASS | TX | Maverick | 48323950500 | 1977 | 0 | 0.80 | 0.29 | 0.42 | 0.42 | 0.92 | 0.06 | 17.95 | 0.43 | 3.35 |
| 14466811 | SOUTH AMARILLO | TX | Potter | 48375014701 | 3453 | 1 | 0.84 | 0.78 | 0.86 | 0.86 | 0.79 | 0.02 | 21.76 | 0.86 | 5.02 |
| 14466911 | HEARNE 1 | TX | Robertson | 48395960502 | 77 | 0 | 0.40 | 0.55 | 0.60 | 0.60 | 0.60 | 0.33 | 20.25 | 0.70 | 3.79 |
| 14467111 | CENTENNIAL | TX | Tarrant | 48439102602 | 3168 | 0 | 0.97 | 0.22 | 0.92 | 0.92 | 0.17 | 0.86 | 19.82 | 0.66 | 4.72 |
| 14467311 | HODGE | TX | Tarrant | 48439105009 | 824 | 1 | 0.76 | 0.72 | 0.75 | 0.75 | 0.48 | 0.43 | 22.30 | 0.89 | 4.78 |
| 14467611 | MOUNT PLEASANT | TX | Titus | 48449950500 | 809 | 0 | 0.64 | 0.29 | 0.42 | 0.42 | 0.24 | 0.02 | 17.15 | 0.36 | 2.39 |
| 14467911 | LAREDO | TX | Webb | 48479000601 | 6460 | 0 | 0.86 | 0.98 | 0.34 | 0.34 | 0.89 | 0.15 | 18.40 | 0.50 | 4.05 |
| 14468011 | TAYLOR | TX | Williamson | 48491021100 | 2916 | 0 | 0.53 | 0.55 | 0.60 | 0.60 | 0.40 | 0.98 | 19.02 | 0.58 | 4.25 |
| 14487511 | AGNESSTREET-YARD | TX | Nueces | 48355000800 | 174 | 0 | 0.24 | 0.44 | 0.53 | 0.53 | 0.63 | 0.06 | 20.94 | 0.77 | 3.20 |
| 14487911 | EAST 1 | TX | Harris | 48201212400 | 937 | 1 | 0.69 | 0.41 | 0.50 | 0.50 | 0.63 | 0.06 | 26.07 | 1.00 | 3.80 |
| 14488111 | EUREKA | TX | Harris | 48201510901 | 9704 | 0 | 0.59 | 0.88 | 0.87 | 0.87 | 0.04 | 0.68 | 17.01 | 0.35 | 4.28 |
| 14488511 | MARKET STREET | TX | Harris | 48201311300 | 8634 | 1 | 0.94 | 0.55 | 0.60 | 0.60 | 0.48 | 0.98 | 24.41 | 0.97 | 5.14 |
| 14488711 | NORTH | TX | Tarrant | 48439105009 | 824 | 1 | 0.64 | 0.50 | 0.99 | 0.99 | 0.33 | 0.06 | 21.75 | 0.85 | 4.36 |
| 14488811 | NORTH YARD | TX | Harris | 48201211501 | 2230 | 1 | 0.86 | 0.87 | 0.87 | 0.86 | 0.50 | 0.11 | 24.30 | 0.97 | 5.04 |
| 14488911 | ODESSA | TX | Ector | 48135003100 | 2748 | 0 | 0.92 | 0.80 | 0.80 | 0.80 | 0.43 | 0.86 | 20.79 | 0.75 | 5.36 |
| 14489011 | ORANGE | TX | Orange | 48361020500 | 974 | 0 | 0.31 | 0.69 | 0.73 | 0.73 | 0.89 | 0.25 | 20.56 | 0.73 | 4.34 |
| 14489111 | SETTEGAST | TX | Harris | 48201230900 | 2013 | 1 | 0.53 | 0.22 | 0.92 | 0.92 | 0.94 | 0.62 | 26.01 | 0.99 | 5.15 |
| 14489211 | SOUTH | TX | Harris | 48201310101 | 4229 | 1 | 0.97 | NA | NA | NA | 0.13 | 0.98 | 22.85 | 0.92 | NA |
| 14489411 | TYLER | TX | Smith | 48423000300 | 1642 | 1 | 0.73 | 0.55 | 0.60 | 0.60 | 0.52 | 0.50 | 22.04 | 0.87 | 4.37 |
| 15528811 | HUGHES SPRINGS | TX | Cass | 48067950700 | 36 | 0 | 0.31 | 0.38 | 0.49 | 0.49 | 0.94 | 0.28 | 20.71 | 0.75 | 3.63 |
| 15528911 | WYLIE | TX | Collin | 48085031308 | 831 | 0 | 0.24 | 0.63 | 0.68 | 0.68 | 0.09 | 0.78 | 17.01 | 0.35 | 3.46 |
| 16910111 | EDINBURG1 | TX | Hidalgo | 48215024003 | 2584 | 0 | 0.82 | 0.09 | 0.09 | 0.09 | 0.06 | 0.86 | 19.56 | 0.63 | 2.66 |
| 16910211 | GARDEN RIDGE | TX | Comal | 48091310804 | 571 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | 0.38 | 0.78 | 18.17 | 0.46 | 2.21 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16910411 | DUBLIN | TX | Erath | 48143950302 | 38 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | 0.74 | 0.20 | 18.20 | 0.47 | 2.00 |
| 16910511 | DIRGIN | TX | Rusk | 48401950101 | 52 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.53 | 0.02 | 18.75 | 0.55 | 1.45 |
| 16910611 | DICKINSON | TX | Galveston | 48167721000 | 564 | 0 | 0.59 | 0.09 | 0.09 | 0.09 | 0.85 | 0.06 | 19.29 | 0.61 | 2.38 |
| 16910711 | DENTON | TX | Denton | 48121021202 | 2638 | 0 | 0.95 | 0.09 | 0.09 | 0.09 | 0.16 | 0.02 | 19.52 | 0.63 | 2.04 |
| 16910811 | DENISON 1 | TX | Grayson | 48181000502 | 2034 | 0 | 0.47 | 0.09 | 0.09 | 0.09 | 0.52 | 0.30 | 17.44 | 0.38 | 1.94 |
| 16910911 | DEL SOL-LOMA LINDA | TX | San Patricio | 48409010900 | 23 | 0 | 0.24 | 0.09 | 0.09 | 0.09 | 0.60 | 0.81 | 18.93 | 0.57 | 2.50 |
| 16911011 | ELM CREEK4 | TX | Maverick | 48323950701 | 10 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.29 | 0.86 | 16.89 | 0.33 | 2.15 |
| 16911111 | DEER PARK9 | TX | Harris | 48201343601 | 0 | 1 | 0.31 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 2.18 |
| 16911211 | DEER PARK7 | TX | Harris | 48201343601 | 0 | 1 | 0.07 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 1.93 |
| 16911311 | KATY | TX | Waller | 48473680100 | 407 | 0 | 0.47 | 0.09 | 0.09 | 0.09 | 0.22 | 0.77 | 15.08 | 0.18 | 1.91 |
| 16911411 | EL CUATRO | TX | Webb | 48479001900 | 2433 | 1 | 0.73 | 0.09 | 0.09 | 0.09 | 0.02 | 0.20 | 21.20 | 0.79 | 2.02 |
| 16911511 | ELECTRA | TX | Wichita | 48485013700 | 378 | 0 | 0.24 | 0.09 | 0.09 | 0.09 | 0.94 | 0.25 | 18.92 | 0.56 | 2.26 |
| 16911611 | ABILENE | TX | Taylor | 48441011000 | 1305 | 0 | 0.78 | NA | NA | NA | 0.72 | 0.20 | 18.37 | 0.49 | NA |
| 16911711 | JUSTIN | TX | Denton | 48121020320 | 555 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.08 | 0.86 | 17.51 | 0.39 | 1.78 |
| 16911811 | ELM CREEK1 | TX | Maverick | 48323950701 | 10 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.29 | 0.86 | 16.89 | 0.33 | 1.83 |
| 16911911 | IOWA PARK | TX | Wichita | 48485013600 | 884 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.53 | 0.92 | 14.27 | 0.11 | 2.24 |
| 16912011 | HUNTER | TX | Comal | 48091310903 | 222 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.20 | 0.73 | 12.69 | 0.04 | 1.31 |
| 16912111 | HOUSTON3 | TX | Harris | 48201320500 | 1915 | 1 | 0.88 | 0.09 | 0.09 | 0.09 | 0.17 | 0.86 | 21.64 | 0.85 | 3.03 |
| 16912211 | HONDO | TX | Medina | 48325000302 | 44 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | 0.25 | 0.72 | 16.09 | 0.25 | 1.82 |
| 16912311 | HOCKLEY | TX | Harris | 48201543100 | 59 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.18 | 0.78 | 19.15 | 0.59 | 1.91 |
| 16912411 | HILLSBORO | TX | Hill | 48217960900 | 546 | 0 | 0.86 | 0.09 | 0.09 | 0.09 | 0.33 | 0.33 | 20.21 | 0.69 | 2.48 |
| 16912511 | HERTY | TX | Angelina | 48005000202 | 104 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.72 | 0.15 | 19.44 | 0.62 | 2.16 |
| 16912611 | HARWOOD2 | TX | Gonzales | 48177000100 | 13 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.69 | 0.92 | 18.72 | 0.55 | 2.50 |
| 16912711 | HARWOOD1 | TX | Gonzales | 48177000100 | 13 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.69 | 0.92 | 18.72 | 0.55 | 2.50 |
| 16912911 | HALSTED | TX | Fayette | 48149970200 | 19 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.79 | 0.83 | 15.75 | 0.23 | 2.20 |
| 16913211 | GREENS PORT | TX | Harris | 48201233300 | 964 | 1 | 0.40 | 0.09 | 0.09 | 0.09 | 0.22 | 0.95 | 25.27 | 0.98 | 2.82 |
| 16913311 | GOODLETT 2 | TX | Hardeman | 48197950100 | 5 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.91 | 0.11 | 17.50 | 0.38 | 1.75 |
| 16913411 | GLAZIER | TX | Hemphill | 48211950300 | 4 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.45 | 0.83 | 14.24 | 0.10 | 1.73 |
| 16913511 | GEORGETOWN | TX | Williamson | 48491021406 | 1003 | 0 | 0.98 | 0.09 | 0.09 | 0.09 | 0.17 | 0.81 | 16.20 | 0.27 | 2.49 |
| 16913611 | GARLAND 2 | TX | Dallas | 48113018501 | 1159 | 1 | 0.69 | 0.09 | 0.09 | 0.09 | 0.48 | 0.20 | 21.18 | 0.78 | 2.44 |
| 16913711 | BEACH CITY | TX | Chambers | 48071710202 | 189 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.14 | 0.89 | 16.53 | 0.30 | 1.67 |
| 16913811 | CACTUS 1 | TX | Moore | 48341950202 | 6 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.27 | 0.92 | 14.60 | 0.13 | 1.77 |
| 16913911 | BRAZOSPORT | TX | Brazoria | 48039664200 | 34 | 1 | 0.07 | 0.09 | 0.09 | 0.09 | 0.85 | 0.11 | 21.64 | 0.84 | 2.15 |
| 16914011 | BORGER 1 | TX | Hutchin-son | 48233950900 | 960 | 0 | 0.53 | 0.09 | 0.09 | 0.09 | 0.83 | 0.06 | 14.84 | 0.15 | 1.84 |
| 16914111 | BLOOMING-TON2 | TX | Victoria | 48469001700 | 44 | 0 | 0.40 | 0.69 | 0.73 | 0.73 | 0.74 | 0.17 | 18.57 | 0.53 | 3.99 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16914211 | BISHOP1 | TX | Nueces | 48355005900 | 24 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.43 | 0.92 | 20.45 | 0.73 | 2.53 |
| 16914311 | BERKELEY PLACE | TX | Tarrant | 48439104302 | 5070 | 0 | 0.91 | 0.09 | 0.09 | 0.09 | 0.10 | 0.30 | 19.06 | 0.58 | 2.17 |
| 16914411 | BELLVILLE | TX | Austin | 48015760502 | 63 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.76 | 0.15 | 19.13 | 0.59 | 2.17 |
| 16914511 | PAMPA 1 | TX | Gray | 48179950100 | 5 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.69 | 0.75 | 14.93 | 0.16 | 1.95 |
| 16914611 | BEAUMONT2 | TX | Jefferson | 48245001700 | 1058 | 1 | 0.47 | 0.09 | 0.09 | 0.09 | 0.85 | 0.55 | 23.98 | 0.96 | 3.10 |
| 16914711 | CALAVERAS LAKE | TX | Bexar | 48029141900 | 119 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.45 | 0.86 | 19.57 | 0.64 | 2.30 |
| 16914811 | BEACH2 | TX | Montgom-ery | 48339693002 | 341 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.33 | 0.25 | 19.95 | 0.67 | 1.59 |
| 16914911 | CAMERON PARK1 | TX | Cameron | 48061012607 | 2107 | 0 | 0.73 | 0.09 | 0.09 | 0.09 | 0.38 | 0.11 | 17.96 | 0.43 | 1.93 |
| 16915011 | BAYTOWN2 | TX | Chambers | 48071710202 | 189 | 0 | 0.24 | 0.09 | 0.09 | 0.09 | 0.14 | 0.89 | 16.53 | 0.30 | 1.85 |
| 16915111 | BAYPORT NORTH INDUSTRIAL PARK | TX | Harris | 48201343700 | 243 | 1 | 0.24 | NA | NA | NA | 0.56 | 0.20 | 22.38 | 0.89 | NA |
| 16915211 | BALLINGER | TX | Runnels | 48399950600 | 13 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | 0.83 | 0.95 | 17.88 | 0.42 | 2.79 |
| 16915311 | AMARILLO 5 | TX | Potter | 48375014401 | 213 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.14 | 0.69 | 15.30 | 0.19 | 1.36 |
| 16915411 | AMARILLO 4 | TX | Potter | 48375014900 | 1163 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.38 | 0.86 | 18.28 | 0.48 | 2.18 |
| 16915511 | AMARILLO 3 | TX | Potter | 48375012200 | 2056 | 0 | 0.86 | 0.55 | 0.60 | 0.60 | 0.43 | 0.36 | 20.27 | 0.70 | 4.11 |
| 16915611 | MONT BELVIEU | TX | Chambers | 48071710100 | 214 | 0 | 0.07 | NA | NA | NA | 0.22 | 0.92 | 16.34 | 0.28 | NA |
| 16915711 | ALVARADO | TX | Johnson | 48251130417 | 244 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.29 | 0.11 | 17.40 | 0.37 | 1.22 |
| 16915811 | ALCOA LAKE | TX | Milam | 48331950800 | 24 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.60 | 0.86 | 18.25 | 0.48 | 2.29 |
| 16915911 | ALAMO | TX | Hidalgo | 48215021903 | 2577 | 0 | 0.69 | 0.09 | 0.09 | 0.09 | 0.81 | 0.02 | 20.23 | 0.69 | 2.49 |
| 16916011 | CORPUS CHRISTI2 | TX | Nueces | 48355006300 | 146 | 0 | 0.53 | 0.69 | 0.73 | 0.73 | 0.63 | 0.15 | 20.41 | 0.72 | 4.17 |
| 16916111 | DAINGERFIELD | TX | Morris | 48343950200 | 43 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | 0.85 | 0.11 | 18.92 | 0.56 | 2.11 |
| 16916211 | DABNEY | TX | Uvalde | 48463950201 | 3 | 0 | 0.07 | NA | NA | NA | 0.79 | 0.98 | 17.45 | 0.38 | NA |
| 16916311 | CRESSON | TX | Hood | 48221160217 | 121 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.33 | 0.81 | 15.92 | 0.24 | 1.72 |
| 16916411 | CORPUS CHRISTI9 | TX | Nueces | 48355006300 | 146 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.63 | 0.15 | 20.41 | 0.72 | 1.84 |
| 16916511 | CORPUS CHRISTI4 | TX | Nueces | 48355006300 | 146 | 0 | 0.24 | 0.09 | 0.09 | 0.09 | 0.63 | 0.15 | 20.41 | 0.72 | 2.02 |
| 16916611 | KAY-BUB | TX | Wichita | 48485012401 | 374 | 0 | 0.47 | 0.09 | 0.09 | 0.09 | 0.48 | 0.86 | 16.28 | 0.27 | 2.36 |
| 16916711 | COPPERAS COVE | TX | Coryell | 48099980000 | 0 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | NA | NA | 9.59 | 0.01 | NA |
| 16916811 | CLUTE3 | TX | Brazoria | 48039664200 | 34 | 1 | 0.07 | 0.09 | 0.09 | 0.09 | 0.85 | 0.11 | 21.64 | 0.84 | 2.15 |
| 16916911 | CLUTE1 | TX | Brazoria | 48039664200 | 34 | 1 | 0.47 | NA | NA | NA | 0.85 | 0.11 | 21.64 | 0.84 | NA |
| 16917011 | CHRIESMAN | TX | Burleson | 48051970202 | 17 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.58 | 0.83 | 16.93 | 0.34 | 2.10 |
| 16917111 | CENTRAL GARDENS2 | TX | Jefferson | 48245011205 | 112 | 0 | 0.59 | 0.09 | 0.09 | 0.09 | 0.35 | 0.89 | 18.48 | 0.52 | 2.63 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16917211 | CARROLLTON 2 | TX | Dallas | 48113020700 | 2162 | 0 | 0.89 | 0.09 | 0.09 | 0.09 | 0.24 | 0.83 | 18.56 | 0.53 | 2.77 |
| 16917311 | CANYON | TX | Randall | 48381022002 | 249 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | 0.14 | 0.98 | 13.64 | 0.07 | 1.78 |
| 16917411 | CANADIAN | TX | Hemphill | 48211950300 | 4 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.45 | 0.83 | 14.24 | 0.10 | 2.06 |
| 16917511 | CAMERON2 | TX | Milam | 48331950402 | 60 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.97 | 0.36 | 19.04 | 0.58 | 2.58 |
| 16917611 | ROGERS | TX | Bell | 48027023402 | 33 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.58 | 0.98 | 18.15 | 0.45 | 2.69 |
| 16917811 | SMITHVILLE | TX | Bastrop | 48021950700 | 450 | 0 | 0.40 | 0.35 | 0.36 | 0.36 | 0.76 | 0.98 | 16.62 | 0.31 | 3.51 |
| 16917911 | SMITH ISLAND | TX | Jefferson | 48245011205 | 112 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.35 | 0.89 | 18.48 | 0.52 | 2.11 |
| 16918011 | SKELLYTOWN 1 | TX | Carson | 48065950100 | 6 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.66 | 0.83 | 13.36 | 0.06 | 1.90 |
| 16918111 | ODEM | TX | San Patricio | 48409011100 | 722 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.66 | 0.98 | 19.53 | 0.63 | 2.95 |
| 16918211 | SEALY1 | TX | Austin | 48015760301 | 68 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.50 | 0.89 | 17.54 | 0.39 | 2.46 |
| 16918311 | SAN ANTONIO2 | TX | Bexar | 48029160902 | 4137 | 1 | 0.91 | 0.09 | 0.09 | 0.09 | 0.72 | 0.17 | 22.86 | 0.92 | 3.00 |
| 16918411 | SAN ANGELO 2 | TX | Tom Green | 48451000300 | 494 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.40 | 0.86 | 16.63 | 0.31 | 2.25 |
| 16918511 | ROUND ROCK4 | TX | Williamson | 48491020604 | 737 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.08 | 0.72 | 12.76 | 0.04 | 1.29 |
| 16918611 | SOIL CON-SERVATION SERVICE SITE 10A | TX | Williamson | 48491020604 | 737 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.08 | 0.72 | 12.76 | 0.04 | 1.29 |
| 16918711 | ROSE CITY | TX | Orange | 48361022000 | 222 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | 0.66 | 0.30 | 20.48 | 0.73 | 2.29 |
| 16918811 | NORTHTECH BUSINESS CENTER | TX | Travis | 48453042000 | 1097 | 0 | 0.59 | 0.83 | 0.24 | 0.24 | 0.12 | 0.68 | 13.20 | 0.06 | 2.76 |
| 16918911 | ROBSTOWN | TX | Nueces | 48355005606 | 219 | 1 | 0.53 | 0.09 | 0.09 | 0.09 | 0.85 | 0.20 | 22.52 | 0.90 | 2.76 |
| 16919011 | ROANOKE | TX | Denton | 48121020312 | 1076 | 0 | 0.59 | NA | NA | NA | 0.06 | 0.78 | 18.10 | 0.45 | NA |
| 16919111 | REID HOPE KING5 | TX | Cameron | 48061014202 | 22 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | 0.40 | 0.06 | 16.32 | 0.28 | 1.33 |
| 16919211 | REID HOPE KING4 | TX | Cameron | 48061012700 | 72 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.29 | 0.98 | 16.41 | 0.29 | 1.90 |
| 16919411 | RAISIN | TX | Victoria | 48469001401 | 170 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.48 | 0.81 | 13.33 | 0.06 | 1.80 |
| 16919511 | QUARRY | TX | Washing-ton | 48477170502 | 26 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.74 | 0.86 | 17.92 | 0.43 | 2.38 |
| 16919611 | PORT NECHES | TX | Jefferson | 48245010800 | 665 | 0 | 0.64 | 0.09 | 0.09 | 0.09 | 0.43 | 0.02 | 19.10 | 0.59 | 1.96 |
| 16919711 | KANE | TX | Hidalgo | 48215020730 | 6911 | 1 | 0.93 | 0.09 | 0.09 | 0.09 | 0.95 | 0.20 | 23.75 | 0.96 | 3.32 |
| 16919811 | ROSENBERG | TX | Fort Bend | 48157675402 | 69 | 0 | 0.47 | 0.09 | 0.09 | 0.09 | 0.29 | 0.95 | 19.15 | 0.59 | 2.57 |
| 16919911 | NORTHCLIFF | TX | Comal | 48091310803 | 164 | 0 | 0.18 | NA | NA | NA | 0.38 | 0.78 | 18.17 | 0.46 | NA |
| 16920011 | WOODGATE | TX | Harris | 48201534002 | 4493 | 1 | 0.76 | 0.09 | 0.09 | 0.09 | 0.25 | 0.25 | 22.16 | 0.88 | 2.41 |
| 16920111 | WINONA | TX | Smith | 48423001701 | 218 | 0 | 0.07 | NA | NA | NA | 0.63 | 0.45 | 20.40 | 0.72 | NA |
| 16920211 | WICHITA FALLS 3 | TX | Wichita | 48485012900 | 124 | 0 | 0.47 | 0.09 | 0.09 | 0.09 | 0.93 | 0.86 | 17.39 | 0.37 | 2.91 |
| 16920311 | PORT ARTHUR | TX | Jefferson | 48245011600 | 5 | 0 | 0.53 | 0.76 | 0.78 | 0.78 | 0.48 | 0.98 | 18.36 | 0.49 | 4.81 |
| 16920411 | WEST MINEOLA | TX | Wood | 48499950700 | 72 | 0 | 0.40 | 0.29 | 0.42 | 0.42 | 0.91 | 0.02 | 19.20 | 0.60 | 3.05 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16920511 | WADSWORTH | TX | Matago-rda | 48321730502 | 4 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.99 | 0.11 | 18.19 | 0.46 | 1.91 |
| 16920611 | VICTORIA2 | TX | Victoria | 48469000700 | 56 | 0 | 0.59 | 0.09 | 0.09 | 0.09 | 0.52 | 0.83 | 15.42 | 0.21 | 2.42 |
| 16920711 | VERNON | TX | Wilbarger | 48487950700 | 181 | 0 | 0.47 | 0.09 | 0.09 | 0.09 | 0.88 | 0.43 | 16.77 | 0.32 | 2.37 |
| 16920811 | NEWBY | TX | Leon | 48289950201 | 9 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.96 | 0.92 | 19.58 | 0.64 | 2.86 |
| 16920911 | THOMPSONS | TX | Fort Bend | 48157675503 | 61 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.09 | 0.77 | 16.24 | 0.27 | 1.47 |
| 16921011 | POINT COMFORT1 | TX | Calhoun | 48057000300 | 7 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.76 | 0.75 | 19.06 | 0.58 | 2.44 |
| 16921111 | NEW BRAUNFELS3 | TX | Comal | 48091310803 | 164 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.38 | 0.78 | 18.17 | 0.46 | 2.07 |
| 16921211 | TEX-MEX INDUSTRIAL PARK | TX | Webb | 48479001816 | 212 | 0 | 0.78 | 0.09 | 0.09 | 0.09 | 0.12 | 0.02 | 14.56 | 0.12 | 1.32 |
| 16921311 | TEJAS INDUSTRIAL PARK | TX | Webb | 48479001715 | 2755 | 0 | 0.69 | 0.09 | 0.09 | 0.09 | 0.06 | 0.72 | 14.24 | 0.10 | 1.85 |
| 16921411 | TAYLOR LAKE VILLAGE | TX | Harris | 48201341600 | 826 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.22 | 0.81 | 19.56 | 0.63 | 2.01 |
| 16921511 | NAVASOT | TX | Grimes | 48185180101 | 71 | 0 | 0.47 | 0.09 | 0.09 | 0.09 | 0.58 | 0.33 | 19.63 | 0.65 | 2.30 |
| 16921611 | SUNRAY 2 | TX | Moore | 48341950202 | 6 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.27 | 0.92 | 14.60 | 0.13 | 1.67 |
| 16921711 | NACOGDO-CHES | TX | Nacogdo-ches | 48347950800 | 1572 | 1 | 0.64 | 0.55 | 0.60 | 0.60 | 0.43 | 0.33 | 21.25 | 0.79 | 3.96 |
| 16921811 | MULE ISLAND | TX | Orange | 48361020300 | 134 | 1 | 0.07 | 0.09 | 0.09 | 0.09 | 0.92 | 0.39 | 23.45 | 0.95 | 2.60 |
| 16921911 | SUGAR LAND | TX | Fort Bend | 48157672202 | 2343 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.20 | 0.73 | 16.11 | 0.26 | 1.86 |
| 16922011 | STEPHENVILLE | TX | Erath | 48143950502 | 4645 | 0 | 0.53 | 0.09 | 0.09 | 0.09 | 0.14 | 0.43 | 18.34 | 0.49 | 1.86 |
| 16922111 | SPRING | TX | Harris | 48201241302 | 1857 | 0 | 0.76 | 0.09 | 0.09 | 0.09 | 0.10 | 0.77 | 16.62 | 0.31 | 2.21 |
| 16922211 | OYSTER CREEK2 | TX | Brazoria | 48039664200 | 34 | 1 | 0.24 | 0.09 | 0.09 | 0.09 | 0.85 | 0.11 | 21.64 | 0.84 | 2.32 |
| 16922311 | THREE RIVERS | TX | Live Oak | 48297950100 | 10 | 0 | 0.24 | 0.61 | 0.66 | 0.66 | 0.60 | 0.78 | 18.71 | 0.54 | 4.10 |
| 16922511 | MONAHANS | TX | Ward | 48475950100 | 5 | 0 | 0.47 | 0.37 | 0.36 | 0.36 | 0.63 | 0.89 | 13.56 | 0.07 | 3.15 |
| 16922611 | MITCHELL LAKE | TX | Bexar | 48029161200 | 220 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | 0.35 | 0.28 | 19.65 | 0.65 | 1.87 |
| 16922711 | MISSOURI PACIFIC RAILYARDS | TX | Webb | 48479001710 | 1 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.20 | 0.70 | 16.80 | 0.33 | 1.57 |
| 16922811 | MISSION | TX | Hidalgo | 48215020105 | 3716 | 1 | 0.88 | 0.09 | 0.09 | 0.09 | 0.96 | 0.45 | 23.55 | 0.95 | 3.51 |
| 16922911 | MINE | TX | Uvalde | 48463950201 | 3 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.79 | 0.98 | 17.45 | 0.38 | 2.49 |
| 16923011 | MILO DISTRIBUTION CENTER | TX | Webb | 48479001726 | 2291 | 0 | 0.53 | 0.09 | 0.09 | 0.09 | 0.05 | 0.68 | 10.45 | 0.01 | 1.55 |
| 16923111 | MCGREGOR | TX | McLennan | 48309003902 | 114 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.48 | 0.86 | 15.68 | 0.23 | 2.24 |
| 16923211 | MATAGORDA COUNTY2 | TX | Matago-rda | 48321730502 | 4 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.99 | 0.11 | 18.19 | 0.46 | 1.91 |
| 16923311 | LUFKIN | TX | Angelina | 48005000400 | 1094 | 1 | 0.82 | 0.55 | 0.60 | 0.60 | 0.72 | 0.20 | 21.09 | 0.77 | 4.28 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16923411 | LONGVIEW HEIGHTS | TX | Harrison | 48203020603 | 231 | 0 | 0.07 | 0.80 | 0.80 | 0.80 | 0.21 | 0.95 | 14.60 | 0.14 | 3.75 |
| 16923511 | MOUNTAIN CITY | TX | Hays | 48209010913 | 654 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.11 | 0.74 | 14.09 | 0.09 | 1.28 |
| 16923611 | LONE STAR | TX | Morris | 48343950200 | 43 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.85 | 0.11 | 18.92 | 0.56 | 1.87 |
| 16923711 | LIBERTY HILL | TX | Williamson | 48491020329 | 670 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.24 | 0.89 | 15.59 | 0.22 | 2.03 |
| 16923811 | LEMONVILLE | TX | Orange | 48361021200 | 129 | 0 | 0.24 | 0.09 | 0.09 | 0.09 | 0.45 | 0.02 | 19.24 | 0.60 | 1.59 |
| 16923911 | LAX | TX | Webb | 48479000200 | 4014 | 0 | 0.89 | 0.09 | 0.09 | 0.09 | 0.94 | 0.43 | 20.60 | 0.74 | 3.27 |
| 16924111 | LAKE MONTICELLO | TX | Titus | 48449950200 | 32 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.72 | 0.15 | 17.62 | 0.40 | 1.61 |
| 16924311 | LA PORTE2 | TX | Harris | 48201343700 | 243 | 1 | 0.18 | 0.09 | 0.09 | 0.09 | 0.56 | 0.20 | 22.38 | 0.89 | 2.10 |
| 16924411 | LA PORTE1 | TX | Harris | 48201343601 | 0 | 1 | 0.53 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 2.39 |
| 16924511 | OWENS-ILLINOIS RESERVOIR | TX | Orange | 48361021100 | 121 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.63 | 0.15 | 19.16 | 0.59 | 1.72 |
| 16924611 | PLEASANTON | TX | Atascosa | 48013960404 | 238 | 0 | 0.47 | 0.09 | 0.09 | 0.09 | 0.45 | 0.75 | 14.70 | 0.14 | 2.09 |
| 16924711 | PLANT RESERVOIR2 | TX | Orange | 48361020500 | 974 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.89 | 0.25 | 20.56 | 0.73 | 2.33 |
| 16924911 | PHILLIPS | TX | Hutchin-son | 48233951000 | 147 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.43 | 0.86 | 11.88 | 0.02 | 1.77 |
| 16925011 | PERRYTON YARD | TX | Ochiltree | 48357950300 | 473 | 0 | 0.53 | 0.09 | 0.09 | 0.09 | 0.48 | 0.17 | 15.13 | 0.18 | 1.64 |
| 16925111 | PEARLAND | TX | Brazoria | 48039660503 | 1060 | 0 | 0.73 | 0.09 | 0.09 | 0.09 | 0.22 | 0.75 | 18.35 | 0.49 | 2.46 |
| 16925211 | CHEVRON PHILLIPS PASADENA | TX | Harris | 48201324102 | 0 | 1 | 0.73 | 0.09 | 0.09 | 0.09 | 0.29 | 0.06 | 25.35 | 0.99 | 2.34 |
| 16925311 | PANHANDLE | TX | Carson | 48065950200 | 7 | 0 | 0.31 | 0.09 | 0.09 | 0.09 | 0.53 | 0.78 | 14.09 | 0.09 | 2.00 |
| 16925411 | LAREDO_YARD | TX | Webb | 48479001816 | 212 | 0 | 0.31 | 0.29 | 0.42 | 0.42 | 0.12 | 0.02 | 15.38 | 0.20 | 1.78 |
| 16925511 | BECKVILLE | TX | Panola | 48365950200 | 19 | 0 | 0.07 | 0.49 | 0.54 | 0.54 | 0.65 | 0.20 | 20.95 | 0.77 | 3.26 |
| 16925611 | BELLMEAD | TX | McLennan | 48309001600 | 1813 | 1 | 0.89 | 0.80 | 0.80 | 0.80 | 0.50 | 0.39 | 21.16 | 0.78 | 4.96 |
| 16925711 | CHICO | TX | Wise | 48497150405 | 43 | 0 | 0.31 | 0.46 | 0.50 | 0.50 | 0.69 | 0.02 | 18.23 | 0.47 | 2.97 |
| 16925811 | DALHART | TX | Dallam | 48111950300 | 1016 | 0 | 0.40 | NA | NA | NA | 0.25 | 0.98 | 14.41 | 0.12 | NA |
| 16925911 | RAY YARD | TX | Grayson | 48181000400 | 834 | 0 | 0.24 | NA | NA | NA | 0.81 | 0.30 | 20.52 | 0.73 | NA |
| 16926011 | DIMMITT | TX | Castro | 48069950200 | 114 | 0 | 0.31 | 0.66 | 0.70 | 0.70 | 0.56 | 0.86 | 15.18 | 0.18 | 3.99 |
| 16926111 | EL PASO 1 | TX | El Paso | 48141001800 | 2796 | 1 | 0.76 | 0.76 | 0.78 | 0.78 | 0.04 | 0.25 | 22.85 | 0.92 | 4.28 |
| 16926211 | TN | TX | Morris | 48343950200 | 43 | 0 | 0.07 | 0.19 | 0.19 | 0.19 | 0.85 | 0.11 | 18.92 | 0.56 | 2.17 |
| 16926311 | ALAMO JUNCTION | TX | Bexar | 48029141800 | 162 | 1 | 0.07 | 0.66 | 0.70 | 0.70 | 0.60 | 0.06 | 21.72 | 0.85 | 3.64 |
| 16926411 | ENNIS | TX | Ellis | 48139061700 | 39 | 0 | 0.07 | 0.84 | 0.84 | 0.84 | 0.40 | 0.83 | 18.80 | 0.55 | 4.38 |
| 16926611 | HEREFORD 2 | TX | Deaf Smith | 48117950600 | 2 | 0 | 0.31 | 0.23 | 0.36 | 0.36 | 0.79 | 0.98 | 14.76 | 0.14 | 3.18 |
| 16926711 | HIGHTOWER | TX | Liberty | 48291700500 | 24 | 0 | 0.07 | 0.39 | 0.96 | 0.96 | 0.65 | 0.25 | 17.76 | 0.41 | 3.68 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{2.5}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16926811 | STORAGE YARD | TX | Harris | 48201212500 | 860 | 1 | 0.76 | 0.37 | 0.94 | 0.94 | 0.02 | 0.51 | 26.48 | 1.00 | 4.53 |
| 16926911 | HOUSTON2 | TX | Harris | 48201324200 | 452 | 1 | 0.91 | 0.09 | 0.09 | 0.09 | 0.58 | 0.06 | 27.10 | 1.00 | 2.83 |
| 16927111 | IRVING | TX | Dallas | 48113010003 | 371 | 1 | 0.64 | 0.49 | 0.54 | 0.54 | 0.09 | 0.06 | 21.09 | 0.77 | 3.14 |
| 16927211 | JASPER | TX | Jasper | 48241950200 | 628 | 1 | 0.31 | 0.49 | 0.54 | 0.54 | 0.77 | 0.28 | 22.32 | 0.89 | 3.83 |
| 16927311 | JEFFERSON COUNTY1 | TX | Jefferson | 48245011402 | 46 | 0 | 0.07 | 0.66 | 0.70 | 0.70 | 0.43 | 0.92 | 18.22 | 0.47 | 3.96 |
| 16927411 | MILLER YARD | TX | Dallas | 48113021100 | 953 | 1 | 0.59 | 0.22 | 0.92 | 0.92 | 0.79 | 0.59 | 21.40 | 0.81 | 4.84 |
| 16927611 | MESQUITE | TX | Dallas | 48113017805 | 1974 | 1 | 0.84 | 0.55 | 0.60 | 0.60 | 0.43 | 0.43 | 22.20 | 0.88 | 4.34 |
| 16927811 | KENDLETON_ INTERMODAL | TX | Fort Bend | 48157675800 | 28 | 0 | 0.07 | 0.99 | 0.34 | 0.34 | 0.82 | 0.30 | 19.09 | 0.59 | 3.45 |
| 16927911 | PAMPA 2 | TX | Gray | 48179950800 | 1231 | 0 | 0.59 | 0.49 | 0.54 | 0.54 | 0.92 | 0.43 | 15.29 | 0.19 | 3.69 |
| 16928011 | PECOS | TX | Reeves | 48389950600 | 2 | 0 | 0.40 | 0.18 | 0.18 | 0.18 | 0.35 | 0.72 | 14.78 | 0.15 | 2.16 |
| 16928111 | PLAINVIEW | TX | Hale | 48189950100 | 491 | 0 | 0.84 | 0.76 | 0.79 | 0.79 | 0.58 | 0.15 | 16.12 | 0.26 | 4.16 |
| 16928211 | QUANAH | TX | Hardeman | 48197950100 | 5 | 0 | 0.31 | 0.49 | 0.54 | 0.54 | 0.91 | 0.11 | 17.50 | 0.38 | 3.29 |
| 16928311 | ZILER | TX | Howard | 48227950100 | 6 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.82 | 0.92 | 16.33 | 0.28 | 3.85 |
| 16928511 | SAN ANTONIO CENTRAL | TX | Bexar | 48029980002 | 0 | 0 | 0.95 | 0.19 | 0.19 | 0.19 | NA | NA | 9.46 | 0.01 | NA |
| 16928611 | MISSION RAIL ELMENDORF | TX | Wilson | 48493000201 | 61 | 0 | 0.07 | 0.46 | 0.50 | 0.50 | 0.56 | 0.89 | 17.51 | 0.39 | 3.38 |
| 16928811 | DAYTON (BNSF) | TX | Liberty | 48291701000 | 108 | 0 | 0.31 | 0.47 | 0.98 | 0.98 | 0.33 | 0.20 | 18.45 | 0.51 | 3.77 |
| 16928911 | SWEETWATER | TX | Nolan | 48353950100 | 10 | 0 | 0.47 | NA | NA | NA | 0.74 | 0.83 | 14.73 | 0.14 | NA |
| 16929011 | TEAGUE | TX | Freestone | 48161000700 | 508 | 0 | 0.40 | 0.49 | 0.54 | 0.54 | 0.81 | 0.43 | 18.94 | 0.57 | 3.77 |
| 16929211 | TENAHA 2 | TX | Shelby | 48419950100 | 32 | 0 | 0.18 | 0.49 | 0.54 | 0.54 | 0.82 | 0.33 | 20.25 | 0.70 | 3.59 |
| 16929311 | WICHITA FALLS 2 | TX | Wichita | 48485010100 | 990 | 1 | 0.76 | 0.23 | 0.36 | 0.36 | 0.76 | 0.47 | 22.16 | 0.88 | 3.82 |
| 16929411 | FORT BLISS | TX | El Paso | 48141010101 | 43 | 0 | 0.53 | 0.09 | 0.09 | 0.09 | 0.01 | 0.70 | 13.40 | 0.07 | 1.58 |
| 16929511 | FLOYDADA | TX | Floyd | 48153950600 | 7 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.88 | 0.02 | 15.45 | 0.21 | 1.78 |
| 16929611 | FERGUSON CREEK RESERVOIR | TX | Harrison | 48203020604 | 31 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.69 | 0.20 | 19.44 | 0.62 | 1.86 |
| 16929711 | FARWELL | TX | Parmer | 48369950300 | 9 | 0 | 0.53 | 0.09 | 0.09 | 0.09 | 0.56 | 0.95 | 14.92 | 0.16 | 2.46 |
| 16929811 | ERINWILDE | TX | Harris | 48201240400 | 986 | 1 | 0.76 | 0.09 | 0.09 | 0.09 | 0.20 | 0.28 | 23.26 | 0.94 | 2.45 |
| 16930111 | ANGLETON 2 | TX | Brazoria | 48039663100 | 183 | 0 | 0.47 | 0.49 | 0.54 | 0.54 | 0.35 | 0.72 | 15.47 | 0.21 | 3.32 |
| 16930211 | VIDOR | TX | Orange | 48361021901 | 133 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.56 | 0.20 | 19.48 | 0.62 | 2.06 |
| 16930411 | WEST ORANGE | TX | Orange | 48361020300 | 134 | 1 | 0.18 | 0.09 | 0.09 | 0.09 | 0.92 | 0.39 | 23.45 | 0.95 | 2.71 |
| 16930511 | AMARILLO 1 | TX | Potter | 48375014300 | 8 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.38 | 0.83 | 17.08 | 0.35 | 1.91 |
| 16930611 | BAYTOWN3 | TX | Chambers | 48071710201 | 626 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.14 | 0.89 | 16.53 | 0.30 | 1.78 |
| 16930711 | BEAUMONT1 | TX | Jefferson | 48245001700 | 1058 | 1 | 0.53 | 0.09 | 0.09 | 0.09 | 0.85 | 0.55 | 23.98 | 0.96 | 3.16 |
| 16930811 | BEAUMONT3 | TX | Jefferson | 48245011700 | 927 | 1 | 0.59 | 0.09 | 0.09 | 0.09 | 1.00 | 0.45 | 22.47 | 0.90 | 3.21 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16930911 | EL PASO 2 | TX | El Paso | 48141002100 | 3247 | 1 | 0.93 | 0.84 | 0.84 | 0.84 | 0.03 | 0.28 | 23.27 | 0.94 | 4.70 |
| 16931011 | PASADENA1 | TX | Harris | 48201324102 | 0 | 1 | 0.64 | 0.39 | 0.96 | 0.96 | 0.29 | 0.06 | 25.35 | 0.99 | 4.29 |
| 16931111 | SUNRAY 1 | TX | Moore | 48341950100 | 8 | 0 | 0.07 | 0.49 | 0.54 | 0.54 | 0.56 | 0.02 | 14.96 | 0.16 | 2.38 |
| 16931211 | CACTUS 2 | TX | Moore | 48341950202 | 6 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.27 | 0.92 | 14.60 | 0.13 | 1.67 |
| 16931311 | CAMERON1 | TX | Milam | 48331950402 | 60 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.97 | 0.36 | 19.04 | 0.58 | 2.58 |
| 16931411 | CENTRAL GARDENS1 | TX | Jefferson | 48245011102 | 2637 | 0 | 0.78 | 0.09 | 0.09 | 0.09 | 0.35 | 0.95 | 17.86 | 0.42 | 2.78 |
| 16931511 | CLUTE2 | TX | Brazoria | 48039664200 | 34 | 1 | 0.07 | 0.09 | 0.09 | 0.09 | 0.85 | 0.11 | 21.64 | 0.84 | 2.15 |
| 16931611 | CORPUS CHRISTI6 | TX | Nueces | 48355006300 | 146 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.63 | 0.15 | 20.41 | 0.72 | 1.95 |
| 16931711 | CORPUS CHRISTI7 | TX | Nueces | 48355006300 | 146 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.63 | 0.15 | 20.41 | 0.72 | 1.95 |
| 16931811 | DEER PARK1 | TX | Harris | 48201324102 | 0 | 1 | 0.40 | 0.09 | 0.09 | 0.09 | 0.29 | 0.06 | 25.35 | 0.99 | 2.01 |
| 16931911 | CORPUS CHRISTI8 | TX | Nueces | 48355006300 | 146 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.63 | 0.15 | 20.41 | 0.72 | 1.95 |
| 16932011 | DEER PARK10 | TX | Harris | 48201343601 | 0 | 1 | 0.40 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 2.26 |
| 16932111 | DEER PARK11 | TX | Harris | 48201343601 | 0 | 1 | 0.18 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 2.04 |
| 16932211 | DEER PARK12 | TX | Harris | 48201343601 | 0 | 1 | 0.24 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 2.10 |
| 16932311 | DEER PARK3 | TX | Harris | 48201343601 | 0 | 1 | 0.24 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 2.10 |
| 16932411 | DEER PARK2 | TX | Harris | 48201343601 | 0 | 1 | 0.40 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 2.26 |
| 16932511 | DEER PARK4 | TX | Harris | 48201343601 | 0 | 1 | 0.24 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 2.10 |
| 16932611 | DEER PARK5 | TX | Harris | 48201343601 | 0 | 1 | 0.07 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 1.93 |
| 16932711 | DEER PARK6 | TX | Harris | 48201343601 | 0 | 1 | 0.07 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 1.93 |
| 16932811 | DEER PARK8 | TX | Harris | 48201343601 | 0 | 1 | 0.18 | 0.09 | 0.09 | 0.09 | 0.69 | 0.06 | 21.61 | 0.83 | 2.04 |
| 16932911 | EAGLE LAKE2 | TX | Colorado | 48089750100 | 23 | 0 | 0.24 | 0.29 | 0.42 | 0.42 | 0.79 | 0.20 | 18.39 | 0.49 | 2.86 |
| 16933011 | ELM CREEK2 | TX | Maverick | 48323950702 | 21 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.29 | 0.86 | 16.89 | 0.33 | 1.83 |
| 16933111 | ELM CREEK3 | TX | Maverick | 48323950701 | 10 | 0 | 0.18 | 0.09 | 0.09 | 0.09 | 0.29 | 0.86 | 16.89 | 0.33 | 1.93 |
| 16933211 | FORT HOOD | TX | Bell | 48027023202 | 1397 | 0 | 0.73 | 0.09 | 0.09 | 0.09 | 0.01 | 0.25 | 14.29 | 0.11 | 1.37 |
| 16933311 | FREEPORT2 | TX | Brazoria | 48039664200 | 34 | 1 | 0.31 | 0.36 | 0.93 | 0.93 | 0.85 | 0.11 | 21.64 | 0.84 | 4.34 |
| 16933611 | GREGGTON 2 | TX | Gregg | 48183000900 | 456 | 1 | 0.64 | NA | NA | NA | 0.76 | 0.53 | 21.76 | 0.86 | NA |
| 16933711 | GREGORY1 | TX | San Patricio | 48409010500 | 325 | 0 | 0.18 | 0.55 | 0.60 | 0.60 | 0.60 | 0.78 | 19.17 | 0.60 | 3.92 |
| 16934011 | OLMITO 1 | TX | Cameron | 48061014402 | 1933 | 0 | 0.59 | 0.80 | 0.80 | 0.80 | 0.11 | 0.73 | 14.40 | 0.12 | 3.94 |
| 16934111 | MATAGORDA COUNTY1 | TX | Matago-rda | 48321730502 | 4 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.99 | 0.11 | 18.19 | 0.46 | 1.91 |
| 16934211 | OYSTER CREEK1 | TX | Brazoria | 48039664200 | 34 | 1 | 0.24 | 0.09 | 0.09 | 0.09 | 0.85 | 0.11 | 21.64 | 0.84 | 2.32 |
| 16934411 | PLANT RESERVOIR1 | TX | Orange | 48361020300 | 134 | 1 | 0.18 | 0.09 | 0.09 | 0.09 | 0.92 | 0.39 | 23.45 | 0.95 | 2.71 |
| 16934511 | REID HOPE KING2 | TX | Cameron | 48061012700 | 72 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.29 | 0.98 | 16.41 | 0.29 | 1.90 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{25}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16934811 | CORPUS CHRISTI1 | TX | Nueces | 48355006300 | 146 | 0 | 0.07 | 0.20 | 0.35 | 0.35 | 0.63 | 0.15 | 20.41 | 0.72 | 2.46 |
| 16934911 | REID HOPE KING1 | TX | Cameron | 48061014202 | 22 | 0 | 0.40 | 0.09 | 0.09 | 0.09 | 0.40 | 0.06 | 16.32 | 0.28 | 1.42 |
| 16935011 | REID HOPE KING3 | TX | Cameron | 48061012700 | 72 | 0 | 0.07 | 0.09 | 0.09 | 0.09 | 0.29 | 0.98 | 16.41 | 0.29 | 1.90 |
| 16935111 | ROUND ROCK2 | TX | Williamson | 48491020607 | 1827 | 0 | 0.78 | 0.09 | 0.09 | 0.09 | 0.06 | 0.69 | 12.93 | 0.05 | 1.86 |
| 16935211 | EL PASO SOUTH/INTER-NATIONAL | TX | El Paso | 48141001900 | 10450 | 1 | 0.78 | NA | NA | NA | 0.04 | 0.53 | 24.03 | 0.96 | NA |
| 16935311 | ROUND ROCK1 | TX | Williamson | 48491020602 | 2881 | 0 | 0.88 | 0.09 | 0.09 | 0.09 | 0.14 | 0.89 | 16.73 | 0.32 | 2.50 |
| 16935511 | ROUND ROCK3 | TX | Williamson | 48491020607 | 1827 | 0 | 0.47 | 0.09 | 0.09 | 0.09 | 0.06 | 0.69 | 12.93 | 0.05 | 1.55 |
| 16935611 | WICHITA FALLS 1 | TX | Wichita | 48485011100 | 693 | 0 | 0.76 | 0.09 | 0.09 | 0.09 | 0.76 | 0.25 | 20.05 | 0.68 | 2.71 |
| 16935711 | ORANGEFIELD | TX | Orange | 48361020300 | 134 | 1 | 0.07 | 0.09 | 0.09 | 0.09 | 0.92 | 0.39 | 23.45 | 0.95 | 2.60 |
| 16935811 | GALENA PARK | TX | Harris | 48201233703 | 934 | 1 | 0.69 | NA | NA | NA | 0.35 | 0.98 | 22.25 | 0.89 | NA |
| 17860611 | ARLINGTON | TX | Tarrant | 48439122300 | 6244 | 1 | 0.92 | 0.22 | 0.92 | 0.92 | 0.05 | 0.25 | 23.14 | 0.94 | 4.21 |
| 17860911 | BAYTOWN 2 | TX | Harris | 48201254300 | 4413 | 1 | 0.76 | 0.55 | 0.60 | 0.60 | 0.27 | 0.02 | 22.71 | 0.91 | 3.72 |
| 17861011 | BEAUMONT 0 | TX | Jefferson | 48245001301 | 1842 | 0 | 0.64 | 0.99 | 0.89 | 0.89 | 0.79 | 0.36 | 20.77 | 0.75 | 5.31 |
| 17861911 | BRYAN | TX | Brazos | 48041000606 | 4119 | 1 | 0.88 | 0.83 | 0.24 | 0.24 | 0.22 | 0.48 | 21.56 | 0.82 | 3.70 |
| 17862911 | CORSICANA | TX | Navarro | 48349970902 | 3008 | 1 | 0.53 | 0.29 | 0.42 | 0.42 | 0.48 | 0.25 | 21.31 | 0.80 | 3.18 |
| 17863211 | DAYTON | TX | Liberty | 48291701000 | 108 | 0 | 0.59 | 0.55 | 0.60 | 0.60 | 0.33 | 0.20 | 18.45 | 0.51 | 3.39 |
| 17864111 | ELDON | TX | Harris | 48201253201 | 930 | 0 | 0.18 | 0.29 | 0.42 | 0.42 | 0.25 | 0.98 | 20.87 | 0.76 | 3.29 |
| 17864811 | FLATONIA | TX | Fayette | 48149970500 | 15 | 0 | 0.24 | NA | NA | NA | 0.81 | 0.78 | 16.14 | 0.26 | NA |
| 17865111 | GLASS YARD | TX | Harris | 48201212400 | 937 | 1 | 0.69 | 0.69 | 0.73 | 0.73 | 0.63 | 0.06 | 26.07 | 1.00 | 4.53 |
| 17865311 | GRAND PRAIRIE | TX | Dallas | 48113015600 | 4124 | 1 | 0.92 | NA | NA | NA | 0.50 | 0.33 | 23.04 | 0.93 | NA |
| 17865711 | HEMPSTEAD | TX | Waller | 48473680502 | 46 | 1 | 0.40 | NA | NA | NA | 0.66 | 0.30 | 21.20 | 0.79 | NA |
| 17867911 | LONGVIEW_2 | TX | Gregg | 48183001100 | 1176 | 1 | 0.73 | 0.80 | 0.80 | 0.80 | 0.74 | 0.47 | 21.11 | 0.78 | 5.11 |
| 17869011 | NEY YARD | TX | Tarrant | 48439123600 | 3685 | 1 | 0.91 | 0.88 | 0.87 | 0.87 | 0.43 | 0.43 | 24.23 | 0.97 | 5.35 |
| 17869111 | NOLTE SPUR | TX | Guada-lupe | 48187210513 | 258 | 0 | 0.18 | 0.35 | 0.36 | 0.36 | 0.35 | 0.81 | 15.65 | 0.23 | 2.63 |
| 17869511 | NORTH SEADRIFT | TX | Calhoun | 48057000501 | 13 | 1 | 0.07 | 0.55 | 0.60 | 0.60 | 0.95 | 0.98 | 21.42 | 0.81 | 4.57 |
| 17870311 | PORT LAREDO | TX | Webb | 48479001710 | 1 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.20 | 0.70 | 16.80 | 0.33 | 2.42 |
| 17872111 | SINCO | TX | Harris | 48201324200 | 452 | 1 | 0.82 | NA | NA | NA | 0.58 | 0.06 | 27.10 | 1.00 | NA |
| 17872311 | SOUTH SAN ANTONIO | TX | Bexar | 48029160902 | 4137 | 1 | 0.86 | 0.22 | 0.92 | 0.92 | 0.72 | 0.17 | 22.86 | 0.92 | 4.73 |
| 17874611 | WEST BAYPORT | TX | Harris | 48201343700 | 243 | 1 | 0.59 | NA | NA | NA | 0.56 | 0.20 | 22.38 | 0.89 | NA |
| 17876211 | PEACH | TX | Tarrant | 48439123200 | 1022 | 0 | 0.78 | NA | NA | NA | 0.18 | 0.95 | 20.18 | 0.69 | NA |
| 17876311 | TOWER 87 | TX | Harris | 48201211700 | 2174 | 1 | 0.69 | 0.29 | 0.42 | 0.42 | 0.89 | 0.53 | 25.44 | 0.99 | 4.23 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{2.5}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18343311 | AMARILLO (UP) | TX | Potter | 48375015400 | 1272 | 1 | 0.84 | NA | NA | NA | 0.43 | 0.36 | 21.23 | 0.79 | NA |
| 18343411 | EL PASO | TX | El Paso | 48141001800 | 2796 | 1 | 0.76 | 0.47 | 0.53 | 0.53 | 0.04 | 0.25 | 22.85 | 0.92 | 3.50 |
| 18343511 | HASLET (ALLIANCE) | TX | Denton | 48121020320 | 555 | 0 | 0.18 | 0.90 | 0.88 | 0.88 | 0.08 | 0.86 | 17.51 | 0.39 | 4.17 |
| 18343611 | HOUSTON SOUTH | TX | Harris | 48201311800 | 4470 | 1 | 0.96 | 0.66 | 0.70 | 0.70 | 0.33 | 0.02 | 24.18 | 0.97 | 4.33 |
| 18343711 | MARKET STREET (UP) | TX | Harris | 48201233400 | 2547 | 1 | 0.59 | NA | NA | NA | 0.69 | 0.25 | 25.11 | 0.98 | NA |
| 18702111 | BAYPORT | TX | Harris | 48201343700 | 243 | 1 | 0.53 | 0.29 | 0.42 | 0.42 | 0.56 | 0.20 | 22.38 | 0.89 | 3.31 |
| 18702211 | GALENA PARK (UP) | TX | Harris | 48201233703 | 934 | 1 | 0.64 | NA | NA | NA | 0.35 | 0.98 | 22.25 | 0.89 | NA |
| 19468811 | KIRBY | TX | Bexar | 48029121404 | 1996 | 0 | 0.82 | 0.99 | 0.89 | 0.89 | 0.69 | 0.53 | 18.61 | 0.54 | 5.35 |
| 19469011 | KING | TX | Hartley | 48205950200 | 4 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.33 | 0.70 | 12.08 | 0.03 | 2.25 |
| 19469111 | WAXAHACHIE | TX | Ellis | 48139060500 | 1501 | 0 | 0.47 | 0.55 | 0.60 | 0.60 | 0.31 | 0.15 | 18.02 | 0.44 | 3.13 |
| 19469211 | KODAK | TX | Gregg | 48183001400 | 268 | 1 | 0.07 | 0.55 | 0.60 | 0.60 | 0.40 | 0.53 | 21.62 | 0.84 | 3.60 |
| 19469411 | JEFFERSON | TX | Marion | 48315950400 | 137 | 0 | 0.40 | 0.69 | 0.73 | 0.73 | 0.94 | 0.25 | 19.58 | 0.64 | 4.37 |
| 19469511 | EGAN | TX | Johnson | 48251130211 | 462 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.33 | 0.81 | 17.53 | 0.39 | 3.36 |
| 19469611 | ECHO | TX | Orange | 48361021000 | 196 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.50 | 0.92 | 17.47 | 0.38 | 3.00 |
| 19469711 | STRATFORD | TX | Sherman | 48421950200 | 3 | 0 | 0.31 | 0.55 | 0.60 | 0.60 | 0.56 | 0.89 | 14.94 | 0.16 | 3.68 |
| 19469811 | TEXAS ELECT | TX | Tarrant | 48439114105 | 159 | 0 | 0.18 | 0.55 | 0.60 | 0.60 | 0.11 | 0.78 | 14.83 | 0.15 | 2.98 |
| 19470011 | MINEOLA | TX | Wood | 48499950800 | 501 | 0 | 0.40 | 0.29 | 0.42 | 0.42 | 0.95 | 0.20 | 20.90 | 0.76 | 3.44 |
| 19674511 | ABILENE | TX | Taylor | 48441011000 | 1305 | 0 | 0.80 | 0.69 | 0.73 | 0.73 | 0.72 | 0.20 | 18.59 | 0.53 | 4.41 |
| 19756211 | BASIN YARD | TX | Harris | 48201211502 | 3050 | 1 | 0.73 | 0.29 | 0.42 | 0.42 | 0.50 | 0.11 | 24.30 | 0.97 | 3.44 |
| 19756311 | BODIE | TX | Gregg | 48183001400 | 268 | 1 | 0.24 | 0.55 | 0.60 | 0.60 | 0.40 | 0.53 | 21.62 | 0.84 | 3.77 |
| 19756411 | DIBOLL | TX | Angelina | 48005001001 | 153 | 1 | 0.53 | 0.29 | 0.42 | 0.42 | 0.79 | 0.89 | 22.38 | 0.90 | 4.23 |
| 19756511 | DITTLINGER | TX | Comal | 48091310803 | 164 | 0 | 0.18 | 0.29 | 0.42 | 0.42 | 0.38 | 0.78 | 18.17 | 0.46 | 2.93 |
| 19756611 | ELDON | TX | Chambers | 48071710201 | 626 | 0 | 0.24 | 0.29 | 0.42 | 0.42 | 0.14 | 0.89 | 16.53 | 0.30 | 2.70 |
| 19756711 | HOSKINS JCT | TX | Brazoria | 48039664200 | 34 | 1 | 0.18 | 0.69 | 0.73 | 0.73 | 0.85 | 0.11 | 21.64 | 0.84 | 4.12 |
| 19756811 | JONESVILLE | TX | Harrison | 48203020104 | 27 | 0 | 0.07 | 0.69 | 0.73 | 0.73 | 0.74 | 0.11 | 18.14 | 0.45 | 3.52 |
| 19756911 | RIO GRANDE | TX | El Paso | 48141001800 | 2796 | 1 | 0.78 | 0.69 | 0.73 | 0.73 | 0.04 | 0.25 | 22.85 | 0.92 | 4.14 |
| 19757011 | SILVER LAKE | TX | Van Zandt | 48467950100 | 43 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.89 | 0.11 | 17.98 | 0.44 | 2.64 |
| 19757111 | SWEETWATER | TX | Nolan | 48353950300 | 718 | 0 | 0.59 | 0.55 | 0.60 | 0.60 | 0.94 | 0.41 | 17.15 | 0.35 | 4.06 |
| 19757211 | TEMPLE | TX | Bell | 48027020800 | 264 | 1 | 0.64 | 0.83 | 0.86 | 0.87 | 0.96 | 0.61 | 21.71 | 0.85 | 5.63 |
| 19757311 | WALL ST | TX | Jefferson | 48245001700 | 1058 | 1 | 0.69 | 0.29 | 0.42 | 0.42 | 0.85 | 0.55 | 23.98 | 0.96 | 4.18 |
| 14468111 | LYNNDYL | UT | Millard | 49027974100 | 11 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.56 | 0.25 | 15.15 | 0.18 | 2.81 |
| 14468511 | SALT LAKE CITY (NORTH YARD) | UT | Salt Lake | 49035100100 | 1921 | 1 | 0.80 | 0.55 | 0.60 | 0.60 | 0.08 | 0.02 | 21.79 | 0.86 | 3.53 |
| 14468611 | PROVO | UT | Utah | 49049980500 | 693 | 0 | 0.73 | 0.84 | 0.84 | 0.84 | 0.07 | 0.45 | 16.36 | 0.28 | 4.05 |
| 14468711 | OGDEN | UT | Weber | 49057201100 | 1697 | 1 | 0.93 | 0.38 | 0.95 | 0.95 | 0.25 | 0.25 | 21.93 | 0.87 | 4.57 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{2.5}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14489611 | ROPER | UT | Salt Lake | 49035111500 | 867 | 1 | 0.88 | 0.61 | 0.99 | 0.99 | 0.10 | 0.02 | 23.32 | 0.94 | 4.53 |
| 14489711 | SALT LAKE CITY 4TH STREET | UT | Salt Lake | 49035114000 | 3569 | 1 | 0.86 | 0.29 | 0.42 | 0.42 | 0.17 | 0.74 | 20.85 | 0.75 | 3.65 |
| 17861811 | BRIGHAM CITY | UT | Box Elder | 49003960500 | 50 | 0 | 0.69 | 0.55 | 0.60 | 0.60 | 0.20 | 0.15 | 15.17 | 0.18 | 2.98 |
| 19464611 | WIP | UT | Weber | 49057210405 | 678 | 0 | 0.64 | 0.29 | 0.42 | 0.42 | 0.08 | 0.98 | 14.94 | 0.16 | 2.99 |
| 19470111 | HYRUM | UT | Cache | 49005001402 | 767 | 0 | 0.31 | 0.29 | 0.42 | 0.42 | 0.15 | 0.15 | 12.93 | 0.05 | 1.78 |
| 19470211 | HELPER | UT | Carbon | 49007000500 | 9 | 0 | 0.24 | 0.55 | 0.60 | 0.60 | 0.31 | 0.20 | 13.93 | 0.08 | 2.60 |
| 19470311 | CLEARFIELD | UT | Davis | 49011125502 | 4337 | 0 | 0.78 | 0.55 | 0.60 | 0.60 | 0.09 | 0.25 | 15.62 | 0.23 | 3.11 |
| 19470411 | CISCO | UT | Grand | 49019000302 | 1 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.35 | 0.11 | 14.36 | 0.11 | 1.78 |
| 19470511 | EMKAY | UT | Grand | 49019000302 | 1 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.35 | 0.11 | 14.36 | 0.11 | 2.41 |
| 19757411 | DELLE | UT | Tooele | 49045130600 | 0 | 0 | 0.07 | 0.55 | 0.60 | 0.60 | 0.20 | 0.41 | 15.31 | 0.19 | 2.63 |
| 14429011 | ROANOKE | VA | Roanoke city | 51770001000 | 1907 | 1 | 0.84 | 0.47 | 0.98 | 0.98 | 0.38 | 0.57 | 17.93 | 0.43 | 4.65 |
| 14468811 | CLIFTON FORGE | VA | Alleghany | 51005070100 | 1388 | 1 | 0.18 | 0.94 | 0.29 | 0.29 | 0.01 | 0.48 | 19.73 | 0.66 | 2.85 |
| 14468911 | COLLIER | VA | Dinwiddie | 51053840500 | 149 | 1 | 0.07 | 0.94 | 0.29 | 0.29 | 0.35 | 0.50 | 19.01 | 0.57 | 3.02 |
| 14469011 | LORTON | VA | Fairfax | 51059422101 | 7319 | 0 | 0.53 | 0.40 | 0.49 | 0.49 | 0.06 | 0.11 | 15.17 | 0.18 | 2.27 |
| 14469111 | ACCA | VA | Henrico | 51087200502 | 1036 | 0 | 0.88 | 0.94 | 0.29 | 0.29 | 0.22 | 0.11 | 16.56 | 0.30 | 3.04 |
| 14469211 | FULTON YARD | VA | Henrico | 51087201503 | 2802 | 0 | 0.53 | 0.94 | 0.29 | 0.29 | 0.15 | 0.57 | 17.85 | 0.42 | 3.19 |
| 14469311 | CREWE | VA | Nottoway | 51135000300 | 75 | 1 | 0.18 | 0.72 | 0.75 | 0.75 | 0.66 | 0.41 | 18.76 | 0.55 | 4.02 |
| 14469411 | BRISTOL | VA | Bristol city | 51520020201 | 3428 | 1 | 0.80 | 0.82 | 0.24 | 0.24 | 0.74 | 0.48 | 20.09 | 0.68 | 4.01 |
| 14469511 | PORTLOCK | VA | Chesa-peake city | 51550020200 | 3794 | 1 | 0.76 | 0.99 | 0.89 | 0.89 | 0.29 | 0.61 | 18.53 | 0.53 | 4.94 |
| 14469711 | LYNCHBURG | VA | Lynchburg city | 51680000400 | 2206 | 1 | 0.59 | 0.94 | 0.29 | 0.29 | 0.56 | 0.60 | 17.75 | 0.41 | 3.68 |
| 14469811 | SANDY HOOK | VA | Lynchburg city | 51680001900 | 822 | 1 | 0.53 | 0.94 | 0.29 | 0.29 | 0.69 | 0.63 | 19.32 | 0.61 | 3.98 |
| 14469911 | NEWPORT NEWS | VA | Newport News city | 51700031200 | 2563 | 1 | 0.73 | 0.94 | 0.29 | 0.29 | 0.63 | 0.58 | 19.53 | 0.63 | 4.09 |
| 14490011 | COLLIER | VA | Petersburg city | 51730811100 | 807 | 0 | 0.24 | 0.94 | 0.29 | 0.29 | 0.43 | 0.46 | 16.79 | 0.33 | 2.98 |
| 18343811 | NORFOLK - NIT | VA | Norfolk city | 51710000902 | 2046 | 0 | 0.24 | 0.82 | 0.24 | 0.24 | 0.00 | 0.36 | 15.10 | 0.18 | 2.08 |
| 14471111 | SEATTLE (ARGO) | WA | King | 53033009300 | 948 | 0 | 0.82 | 0.80 | 0.80 | 0.80 | 0.09 | 0.86 | 20.50 | 0.73 | 4.90 |
| 14471211 | AUBURN | WA | King | 53033030801 | 2752 | 1 | 0.80 | 0.41 | 0.51 | 0.51 | 0.20 | 0.54 | 22.60 | 0.91 | 3.88 |
| 14471311 | INTERBAY (BALMER) | WA | King | 53033005804 | 3022 | 0 | 0.76 | 0.41 | 0.96 | 0.96 | 0.06 | 0.98 | 17.69 | 0.40 | 4.53 |
| 14471711 | BAY | WA | Pierce | 53053060200 | 302 | 1 | 0.92 | 0.48 | 0.98 | 0.98 | 0.14 | 0.30 | 20.39 | 0.71 | 4.52 |
| 17864711 | FIFE | WA | Pierce | 53053940002 | 826 | 0 | 0.69 | 0.29 | 0.42 | 0.42 | 0.24 | 0.36 | 21.18 | 0.78 | 3.20 |
| 17866811 | KENT | WA | King | 53033029702 | 1047 | 1 | 0.53 | 0.29 | 0.42 | 0.42 | 0.43 | 0.39 | 23.26 | 0.94 | 3.41 |

| Yard ID | Site Name | State | County | GEOID | Pop. per Square Mile | DACSTS | Schools Rank | $NO_x$ Rank | $PM_{10}$ Rank | $PM_{2.5}$ Rank | Heart Rank | Asthma Rank | DAC Score | DAC Rank | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14421611 | NEENAH | WI | Winneba-go | 55139003300 | 3334 | 0 | 0.82 | 0.37 | 0.48 | 0.48 | 0.21 | 0.30 | 15.36 | 0.20 | 2.87 |
| 14474011 | NORTH LA CROSSE | WI | La Crosse | 55063000100 | 1729 | 0 | 0.59 | 0.74 | 0.76 | 0.76 | 0.33 | 0.28 | 14.76 | 0.15 | 3.61 |
| 14474211 | BUTLER | WI | Milwaukee | 55079090100 | 2341 | 0 | 0.47 | 0.69 | 0.73 | 0.73 | 0.53 | 0.95 | 16.54 | 0.30 | 4.40 |
| 14474411 | MUSKEGO | WI | Milwaukee | 55079186800 | 786 | 1 | 0.99 | 0.88 | 0.25 | 0.25 | 0.98 | 0.54 | 23.10 | 0.93 | 4.82 |
| 14474511 | STEVENS POINT | WI | Portage | 55097960800 | 1838 | 0 | 0.73 | 0.86 | 0.85 | 0.85 | 0.33 | 0.11 | 13.66 | 0.07 | 3.81 |
| 14474611 | JANESVILLE | WI | Rock | 55105001400 | 314 | 0 | 0.18 | 0.69 | 0.73 | 0.73 | 0.43 | 0.36 | 15.45 | 0.21 | 3.32 |
| 14490711 | FOND DU LAC (SHOPS) | WI | Fond du Lac | 55039041300 | 535 | 0 | 0.47 | 0.37 | 0.94 | 0.94 | 0.52 | 0.28 | 15.38 | 0.20 | 3.71 |
| 17860111 | ADAMS | WI | Adams | 55001950400 | 49 | 1 | 0.31 | 0.80 | 0.80 | 0.80 | 0.94 | 0.41 | 17.17 | 0.36 | 4.42 |
| 17866111 | ITASCA | WI | Douglas | 55031021000 | 96 | 0 | 0.18 | 0.55 | 0.60 | 0.60 | 0.29 | 0.41 | 15.20 | 0.19 | 2.82 |
| 17871711 | SHEBOYGAN | WI | Sheboy-gan | 55117000900 | 1593 | 0 | 0.82 | 0.29 | 0.42 | 0.42 | 0.27 | 0.98 | 15.02 | 0.17 | 3.36 |
| 18305311 | LA CROSSE | WI | La Crosse | 55063000200 | 1993 | 0 | 0.53 | 0.77 | 0.23 | 0.23 | 0.21 | 0.33 | 14.90 | 0.15 | 2.45 |
| 18312711 | SUPERIOR | WI | Douglas | 55031020800 | 370 | 0 | 0.47 | 0.45 | 0.97 | 0.97 | 0.48 | 0.25 | 14.59 | 0.13 | 3.71 |
| 18700211 | ALTOONA (UP) | WI | Eau Claire | 55035000401 | 755 | 0 | 0.47 | 0.80 | 0.80 | 0.80 | 0.27 | 0.11 | 12.48 | 0.03 | 3.27 |
| 18700511 | STINSON AVE | WI | Douglas | 55031020800 | 370 | 0 | 0.53 | 0.77 | 0.23 | 0.23 | 0.48 | 0.25 | 14.59 | 0.13 | 2.61 |
| 19464811 | NORTH MILWAUKEE | WI | Milwaukee | 55079186500 | 4361 | 1 | 0.95 | 0.29 | 0.42 | 0.42 | 0.18 | 0.33 | 20.29 | 0.71 | 3.30 |
| 19464911 | BELGIUM | WI | Ozaukee | 55089610102 | 103 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.18 | 0.02 | 10.35 | 0.01 | 1.41 |
| 14472811 | QUINNIMONT | WV | Fayette | 54019021100 | 22 | 0 | 0.07 | 0.94 | 0.29 | 0.29 | 0.98 | 0.54 | 18.60 | 0.53 | 3.65 |
| 14473111 | DICKINSON | WV | Kanawha | 54039011800 | 33 | 1 | 0.31 | 0.19 | 0.19 | 0.19 | 0.02 | 0.48 | 19.52 | 0.63 | 2.02 |
| 14473411 | BLUEFIELD | WV | Mercer | 54055001900 | 323 | 1 | 0.24 | 0.88 | 0.25 | 0.25 | 0.02 | 0.65 | 20.14 | 0.68 | 2.99 |
| 14473511 | WILLIAMSON | WV | Mingo | 54059957400 | 430 | 1 | 0.31 | 0.45 | 0.20 | 0.20 | 0.03 | 0.62 | 19.41 | 0.62 | 2.44 |
| 14473611 | GRAFTON | WV | Taylor | 54091964900 | 68 | 0 | 0.24 | 0.94 | 0.29 | 0.29 | 0.98 | 0.50 | 18.76 | 0.55 | 3.80 |
| 14473711 | PARKERSBURG LOW | WV | Wood | 54107011000 | 1218 | 0 | 0.59 | 0.94 | 0.29 | 0.29 | 0.02 | 0.63 | 18.44 | 0.51 | 3.27 |
| 14490911 | ALLOY | WV | Fayette | 54019020800 | 103 | 0 | 0.07 | 0.45 | 0.20 | 0.20 | 0.98 | 0.43 | 18.65 | 0.54 | 2.87 |
| 14491011 | PARKERSBURG HIGH | WV | Wood | 54107000701 | 3030 | 0 | 0.78 | 0.94 | 0.29 | 0.29 | 0.99 | 0.67 | 17.26 | 0.36 | 4.33 |
| 14474811 | GREYBULL | WY | Big Horn | 56003962700 | 4 | 1 | 0.31 | 0.65 | 0.69 | 0.69 | 0.76 | 0.06 | 15.53 | 0.22 | 3.37 |
| 14475211 | RAWLINGS | WY | Carbon | 56007967700 | 396 | 0 | 0.40 | 0.55 | 0.60 | 0.60 | 0.16 | 0.92 | 12.26 | 0.03 | 3.27 |
| 14475511 | CHEYENNE | WY | Laramie | 56021000200 | 1576 | 1 | 0.86 | 0.55 | 0.60 | 0.60 | 0.43 | 0.30 | 16.27 | 0.27 | 3.62 |
| 14476411 | GREEN RIVER | WY | Sweetwa-ter | 56037970601 | 111 | 0 | 0.64 | 0.69 | 0.73 | 0.73 | 0.16 | 0.02 | 14.47 | 0.12 | 3.09 |
| 14476511 | ROCK SPRINGS | WY | Sweetwa-ter | 56037971000 | 36 | 0 | 0.47 | 0.29 | 0.42 | 0.42 | 0.18 | 0.83 | 13.80 | 0.08 | 2.69 |
| 18312811 | CASPER | WY | Natrona | 56025000200 | 1948 | 1 | 0.53 | 0.67 | 0.71 | 0.71 | 0.63 | 0.36 | 17.16 | 0.36 | 3.96 |
| 18344011 | CHEYENNE | WY | Laramie | 56021001000 | 3610 | 0 | 0.76 | 0.73 | 0.76 | 0.76 | 0.24 | 0.02 | 13.72 | 0.08 | 3.34 |
| 19465011 | SPEER | WY | Laramie | 56021001902 | 5 | 0 | 0.07 | 0.29 | 0.42 | 0.42 | 0.25 | 0.83 | 13.05 | 0.05 | 2.33 |

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