U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

FREIGHT OPERATIONAL STRATEGIES

Freight operational strategies optimize goods movements and mitigate environmental impact, particularly around ports and congested freight corridors, contributing to a more sustainable and resilient supply chain.

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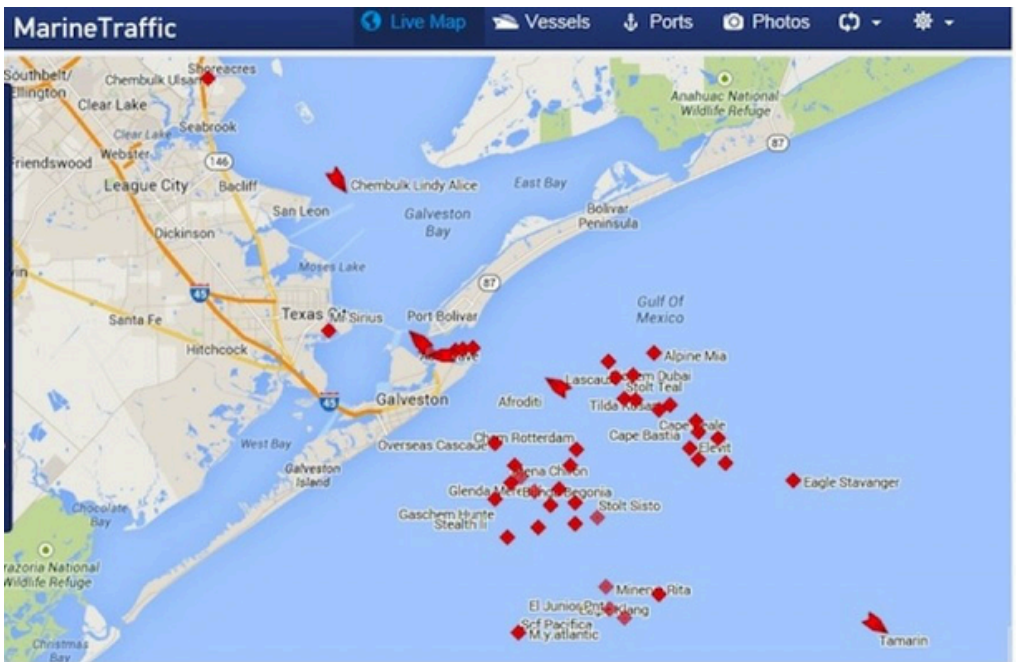
OVERVIEW

Best Suited for:
Long Term & Short Term
Urban, Suburban, Rural

Freight transportation is a critical component of global commerce and economic vitality. However, goods movement is a significant contributor to greenhouse gas (GHG) emissions and can expose workers and people who live near ports and freight corridors to harmful levels of air pollution and noise. According to the International Energy Agency, **freight transport represents about 8% of global greenhouse gas emissions.**

By leveraging next-generation, clean technologies and practices at ports, State and local governments, alongside port authorities and freight operators, **can improve supply chain efficiency and reduce environmental impact.** Freight operational strategies, such as advanced vessel scheduling and truck appointment systems, can reduce GHG emissions and air pollution and provide time and cost savings. Close collaboration and coordination between the freight industry and communities is key to maximizing these benefits.

Learn more about different freight operational strategies below.



A screenshot of the MarineTraffic Live Map, showing tankers waiting to enter the ports of Houston, Texas City and Galveston (Source: EPA, 2024).

JUMP TO: Overview | GHG Reduction Potential | Co-Benefits | Cost Considerations
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Freight operational strategies can be broadly categorized into the following groups

Scheduling and Planning

Optimizing schedules for arrivals, departures, and operations such as loading and unloading, and fueling, can significantly reduce congestion and idling times. Utilizing real-time data and communication tools can further enhance efficiency by facilitating coordinated operations. This translates to less queuing and unnecessary engine operation, leading to lower emissions.

Innovative Last Mile Delivery Solutions

These strategies aim to reduce emissions and congestion by optimizing delivery processes and leveraging emerging technologies. Approaches may include micromobility deliveries, consolidated deliveries, off-peak delivery (Read the Off-peak Delivery page), and delivery lockers.

Read more at the *Micromobility Deliveries, Microhubs, and Last-Mile Solutions* page.

Read more at the *Off-peak Delivery* page.

Regulation and Compliance

Implementing clear and enforceable regulations, like anti-idling ordinances, incentivizes wider adoption of clean, environmentally friendly practices. These regulations establish a well-defined framework for reducing idling emissions in specific zones, such as near schools, hospitals, residential areas, ports, railyards, and truck stops, where people are often exposed to concentrated air pollutants. By promoting widespread compliance, anti-idling ordinances contribute to cleaner air in these sensitive locations. Regulations are most effective when complemented with workforce development and training.

Read more at the Idle Reduction Technologies & Strategies page.

Supply Chain Optimization

Optimizing inventory management, packaging and distribution processes, reduces waste and emissions associated with inefficient logistics practices.

Optimal Mode Choice

Freight transportation can be more efficient and reliable when all modes of freight transportation are considered, and the optimal mode is selected. Private industry should consider intermodal freight maritime and rail routes where feasible, to reduce emissions and avoid congestion on roadways.

Read more at the Multimodal and Intermodal Freight Planning page.

Alternative Fuels and Technologies

Promoting the use of zero-emission and low carbon intensity fuels, such as electric vehicles, and hybrid propulsion systems, reduces emissions and leads to cost savings.

Read more at the Electric Vehicle Charging Infrastructure page.

Operations Streamlining

Improving on freight operations through efficient scheduling, routing, and load consolidation helps minimize fuel consumption, reduce emissions, and leads to cost savings.

Specific freight operational practices and procedures may include:

Port Management Information Systems (PMIS)

These electronic tracking systems monitor ship movements, cargo manifests, truck arrivals/departures, and equipment availability. PMIS may focus on a subset of port functions or encompass all freight movement activities, integrating multiple efficiency improvement strategies. Port functions that may be managed by PMIS include:

Advanced Vessel Scheduling: *Also known as virtual vessel arrival, informs vessels about potential delays at destination ports, helping them align arrival times with berth availability and minimize vessel waiting times and associated anchorage emissions. In addition, these systems can help vessel operators optimize their voyage speeds, resulting in further potential fuel savings.*
Many major U.S. ports have implemented PMIS to varying extents including the Port of Virginia, Port Authority of New York and New Jersey, Port of Oakland, and the Port of Los Angeles.

Optimized Drayage Operations: *Drayage efficiency can be improved through various gate management strategies including truck appointment systems and extended operation hours, both of which shift truck arrivals away from peak periods and reduce average wait times at the terminal gates.*

Idle Reduction Technologies (IRT)

IRTs reduce emissions by enabling operators to power essential functions without relying on main engines. This may include shore power, auxiliary power units, battery air conditioning systems, automatic engine stop/start systems, or electrified parking stops.

Read the *Idle Reduction Technologies & Strategies* page.

Just-in-Time (JIT) & Inventory Management

JIT is a form of inventory management that requires working closely with suppliers so that raw materials arrive as production is scheduled to begin, but no sooner. The goal is to have the minimum amount of inventory on hand to meet demand.

Operator Comfort Stations

Offering climate-controlled rest areas at truck stops and railyards reduces idling by ensuring drivers have a comfortable alternative to running engines for climate control during rest breaks.

GREENHOUSE GAS REDUCTION POTENTIAL

This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.

FREIGHT EMISSIONS IN CONTEXT

Nearly three-quarters of the world's cargo is moved by ocean-going vessels, but road vehicles make of the majority (about 65%) of freight-related emissions.

In 2019, the three largest ports in the United States in terms of volume processed—the Ports of Los Angeles, Long Beach, and New York and New Jersey—emitted over 2.5 million tons of carbon dioxide equivalents (CO_2e). This estimate includes emissions from ocean-going vessels at port, harbor craft, cargo handling equipment, locomotives, and heavy-duty vehicles (Bertrand and Williams, 2022).

Check out the MIT Climate Portal for more information about how we move our freight.

In 2022, international shipping accounted for about 2% of global energy-related CO2 emissions. Scaling up low- and zero-emission fuels, such as biofuels, methanol, and electricity, is the key to decarbonizing the shipping industry (IEA, 2023).

DRAYAGE TRUCKS

In the National Port Strategy Assessment, the Environmental Protection Agency (EPA) estimates that reducing long-haul truck idle and creep time by 10% reduces CO_2 emissions by 2.6% (EPA, 2016).

If a port with an annual average drayage truck volume of 300,000 and an average turn time of 1.5 hours implemented a gate management strategy that lowered turnarounds to 0.8 hours, they could reduce annual CO_2 emissions by 862 tons per year (EPA, 2021a).

The Global Container Terminals (GCT) Bayonne facility implemented a truck appointment system with a 70% reservation adoption rate. This program

significantly reduced truck turnaround times by 40% during appointment hours leading to CO_2 savings of 21,000 tonnes in 2017. That's equivalent to taking roughly 4,500 passenger cars off the road (EPA, 2018).

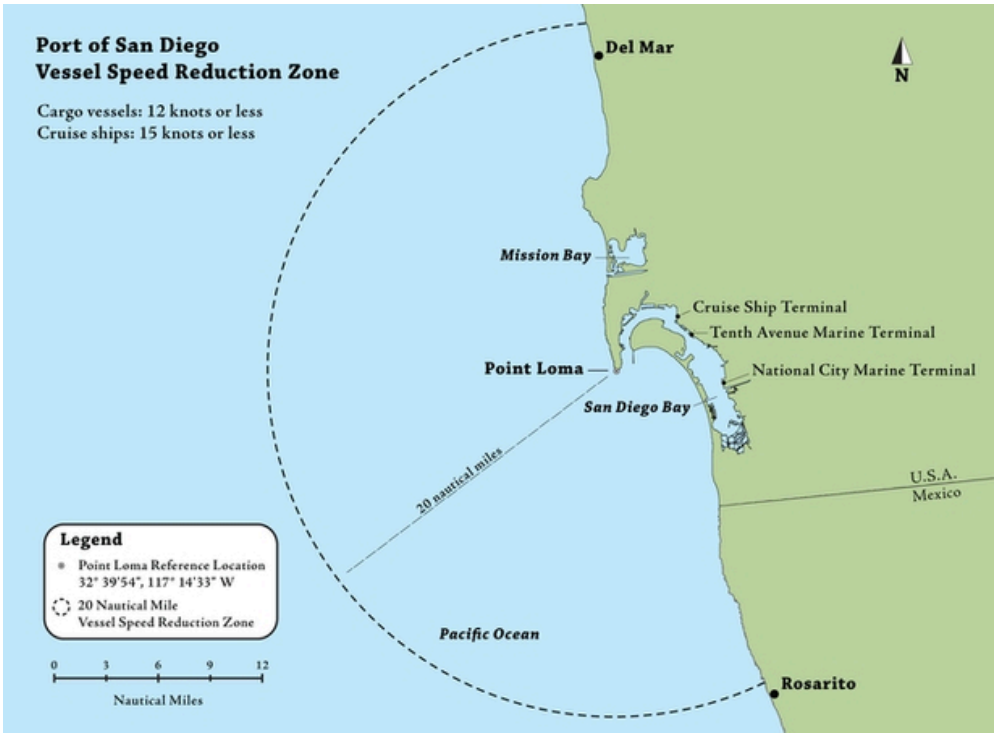
Typical Port Emission Impact for Each 10% Reduction in Idle/Creep Time, 2020 and 2030. (Source: EPA, 2016)

Strategy	NOx		$PM_{2.5}$		CO_2	
	Tons	Percent	Tons	Percent	Tons	Percent
10% reduction in Idle and Creep time	-22	-2.0%	-2	-2.6%	-8,940	-2.6%

OCEAN GOING VESSELS

If an oil tanker with Tier 1 medium speed diesel propulsion engines using marine gas oil originally scheduled to arrive at a port in 184 hours increased its total trip time to 196 hours while en route to avoid an anticipated wait time of 12 hours at anchorage, it could avoid 2.30 tons of CO_2 emissions (EPA, 2021b).

Reducing vessel speeds decreases fuel consumption and emissions near port areas. San Diego, Los Angeles, and New York/New Jersey have established vessel speed reduction (VSR) zones beginning at 20 to 40 nautical miles from shore. As one example, the Port of Los Angeles VSR reduced average vessel speeds to 12 knots within 24 nautical miles, resulting in 37% CO2 emissions savings (EPA VSR, n.d.).



Port of San Diego Vessel Speed Reduction Zone (EPA VSR, n.d.).

CO-BENEFITS

This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.

SAFETY

Reduced engine noise associated with idling can create a safer working environment for port personnel. Regular exposure to high noise levels can lead to occupational hearing loss, which is associated with heart problems, cognitive decline, and poor mental health (CDC, 2024).

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ACCESSIBILITY AND EQUITY

Near-port communities are often low-income communities of color and suffer disproportionate impacts from port operations. Addressing noise and air pollution from truck traffic, train traffic, and idling vessels can reduce impacts on these communities (EPA, 2023; EPA, 2024).

For resources on community-port collaboration, including toolkits, roadmaps, and primers, visit the EPA Ports Initiative site.

ECONOMIC GROWTH

Idle reduction operational strategies, such as advanced scheduling, contribute to smoother operations by minimizing delays. This translates to increased efficiency, potentially leading to higher throughput (EPA, 2019).

Ports can implement several programs and policies that spur investment in local entrepreneurs and the local workforce. These programs can be tailored to emphasize investments in near-port communities and/or communities experiencing high rates of poverty, unemployment and underemployment (EPA, n.d.).

According to the American Association of Port Authorities, deepwater ports in the U.S. supported 541,946 jobs in 2014. In addition, port activity generated over 23 million jobs in related sectors and through their overall economic impact on the surrounding communities (American Association of Port Authorities, 2014).

AIR QUALITY AND HEALTH

Port operations can impact air quality, water quality and land use. Research suggests idling may contribute up to 34% or more to local air pollution levels (Lee et. al., 2017). By increasing port operational efficiency and reducing the movement and idling of vessels, vehicles, and equipment, port management information systems (PMIS) can significantly reduce port-related emissions and noise which can improve the health of port workers and nearby communities (EPA, 2016; EPA, 2024).

Vessel speed reduction zones can have significant benefits for near-port air quality. If a container ship with a typical cruising speed of 21 knots reduced its speed by 20% to 16.8 knots, it would see a reduced engine load of up to 50% and corresponding reductions in fuel consumption and NOx and PM emissions (EPA VSR, n.d.).

COST SAVINGS

Vessel operators typically travel at full speed to destination ports. Knowing about berthing delays in advance allows them to reduce their speed, resulting in fuel savings and emissions reductions en route (EPA, 2021b).

Global Container Terminals (GCT) estimates that an integrated appointment system at the GCT Bayonne facility at the Port of New York and New Jersey improved truck turn times by over 40% (EPA, 2018).

A typical long-haul combination truck that eliminates unnecessary idling could save over 900 gallons of fuel each year (EPA, 2019).

COST CONSIDERATIONS

COST OF IMPLEMENTATION

Anti-idling Programs: The capital costs for implementing and maintaining an anti-idling policy are low, typically limited to signage (around $50) and incorporating the policy into existing employee training sessions (EPA, 2019).

Comfort Stations: Providing basic amenities like restrooms at facilities incurs minimal to no cost. However, enhancing these areas with amenities like comfortable seating, vending machines, Wi-Fi, and electrical outlets will increase costs depending on the level of improvement chosen (EPA, 2019).

Port Management Information Systems (PMIS): PMIS implementation costs vary significantly depending on the size and complexity of your port operation. Factors include installation costs, software licenses, and any necessary equipment (EPA, 2024).

Cost savings from implementing a PMIS can be sizable as a result of reduced fuel consumption, and reduced fees and fines associated with idling and demurrage fees (EPA, 2021a).

Extended Gate Hours: Labor costs associated with extended hours will depend on staffing needs, wages, and benefits.

FUNDING OPPORTUNITIES

EPA's **Clean Ports Program** provides for investment in clean, zero-emission port equipment and technology; to conduct relevant planning or permitting in connection with the purchase or installation of such equipment or technology; and to help ports develop climate action plans to reduce air pollutants at U.S. ports.

FHWA's **Congestion Mitigation Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. This includes certain freight projects that reduce emissions. For more information, please see the CMAQ Interim Guidance.

EPA's **Diesel Emissions Reduction Act (DERA) Program** funds grants and rebates that protect human health and improve air quality by reducing harmful emissions from diesel engines.

USDOT's **Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Discretionary Grant program** funds critical infrastructure projects across the country, prioritizing sustainability and equitable access.

FHWA's **Truck Emissions at Port Facilities (RTEPF) Grant Program** provides funding to test, evaluate, and deploy projects that reduce port-related emissions from idling trucks. Eligible projects include port electrification and efficiency improvements, focusing on heavy-duty commercial vehicles, and other related projects.

Honolulu, Hawaii: Truck Emissions at Port Facilities Grant Award The Hawaii Department of Transportation will receive $5.2 million to modernize port gates and automate improvements at the Sand Island Terminal in Honolulu Harbor. The improvements will reduce truck processing times, queueing delays, cut port-related emissions from idling trucks and make port operations more efficient.

San Juan, Puerto Rico: Truck Emissions at Port Facilities Grant Award Crowley Logistics, Inc. will receive $3.8 million to reduce truck emissions, queueing, idling and traffic congestion at the Isla Grande Terminal at the Port of San Juan in Puerto Rico. The project includes replacing diesel-powered trucks with electric utility tractor rigs and installing fast chargers. Crowley's supply chain operations in the Southeast and Gulf Coast account for more than 60% of domestic cargo moved to/from Puerto Rico.

Idle Reduction Equipment Excise Tax Exemption: Qualified on-board idle reduction devices and advanced insulation are exempt from the federal excise tax imposed on the retail sale of heavy-duty highway trucks and trailers. The exemption also applies to the installation of qualified equipment on vehicles after the vehicles have been placed into service.

MARAD's **Port Infrastructure Development Program** supports projects that improve the safety, efficiency, and reliability of moving goods into, out of, around, or within ports.

COMPLEMENTARY STRATEGIES

IRTs can work alongside other operational improvements like traffic management systems or optimized scheduling to further streamline port operations and reduce overall environmental impact.

Upgrading existing engines with cleaner technology or transitioning to zero-emission alternatives like electric trucks or hydrogen-powered cargo handling equipment can significantly improve air quality and contribute to achieving ambitious climate goals.

The relationship between intermodal freight and freight operational improvements lies in how operational enhancements can improve the effectiveness of intermodal freight while reducing GHG emissions. For example, real-time tracking and data analytics can optimize intermodal routes, minimize transit times, and improve supply chain visibility. Automation and digitalization can streamline intermodal operations, reducing manual errors and delays.

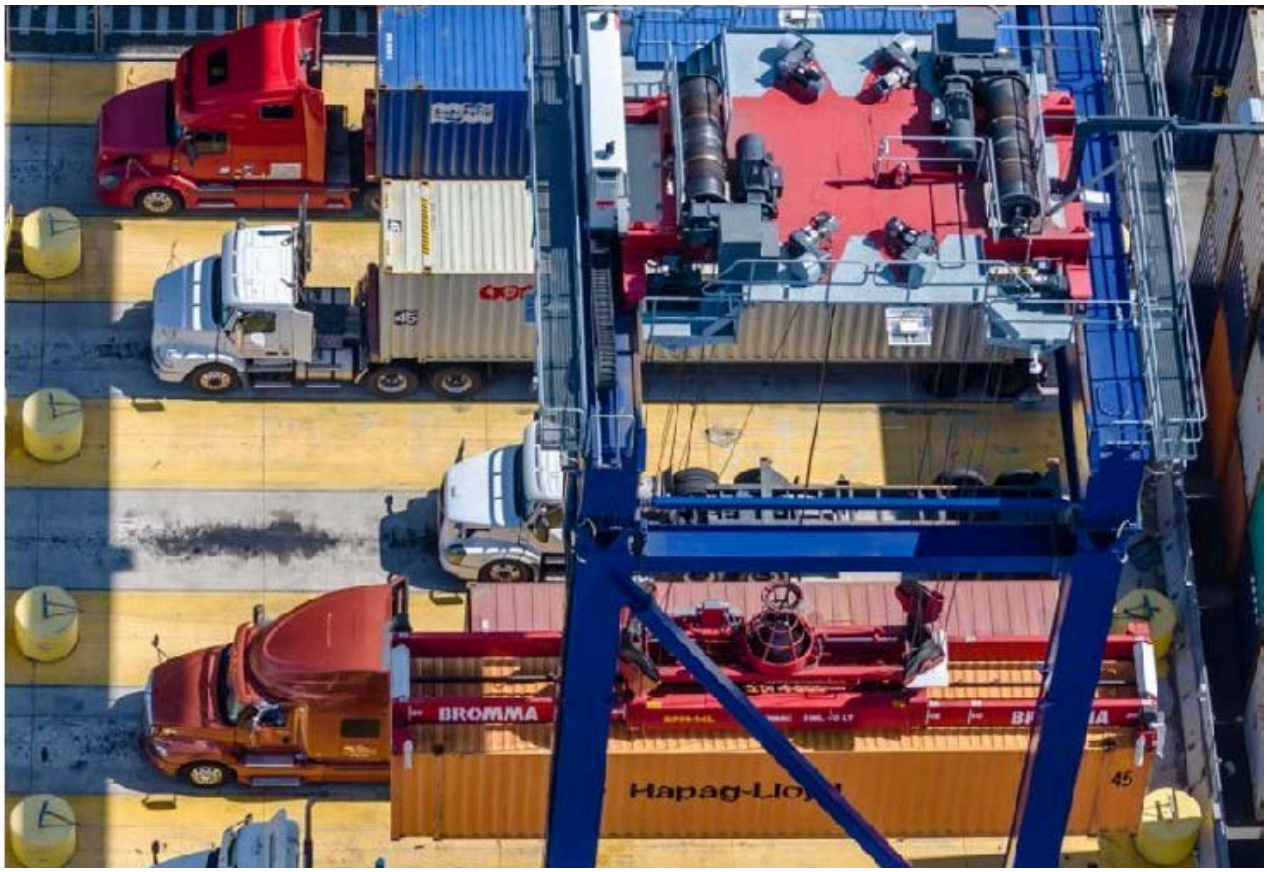
Leveraging compact vehicles like cargo bikes, drones, and delivery robots as agile, last-mile solutions enhances the final, and often complex and costly, component of freight delivery.

By scheduling deliveries during non-peak hours, off-peak deliveries enhance operational efficiency, enhance reliability of timely deliveries, and reduces emissions caused by congestion.

View All Strategies

CASE STUDIES

MIAMI, FLORIDA: TRUCK EMISSIONS AT PORT FACILITIES GRANT AWARD



Source: U.S. EPA Ports Initiative

Jacintoport International will receive $1.8 million to install new terminal operating systems at the Seaboard Marine Port in Miami. The terminal improvements will reduce truck idling time at the gates by at least 10 minutes, which, in turn, will ease truck congestion within the port and roads leading to the ports. The new system will improve the efficiency of trucks picking up or dropping off containers in the yard, reducing their operating time, the amount of carbon emissions, air pollutants and noise associated with idling trucks and equipment.

PORT OF VIRGINIA

The Port of Virginia is one of the fastest growing ports on the East Coast, its largest terminal, the Norfolk International Terminal, encompasses 567 acres and has over 2,147,200 twenty-foot equivalent unit (TEU) capacity. However, trucks servicing the port often experienced lengthy wait times, which created bottlenecks and led to vehicle idling. To relieve congestion, the port implemented an electronic appointment system in 2014.

Source: Port of Virginia

What is TEU?

TEU, or Twenty-foot Equivalent is commonly used unit to determine cargo capacity.

The newly integrated system works across various port operations and includes:

- A reservation system for gate appointments and support.
- A community portal for import and export cargo and vessel schedules.
- A mobile app for import container availability.
- A drayage truck registry with RFID tag support, distribution, and management services.

Furthermore, the system allows for two-way data flows with other supply chain stakeholders. This single window collaboration platform has helped decrease truck turn times by nearly 50%, leading to improved traffic conditions and a 20% reduction in truck-related emissions (EPA, 2021a).

IMPLEMENTING FREIGHT OPERATIONAL STRATEGIES: **WHAT TO READ NEXT**

Enacting anti-idling regulations or time limits can be a readily implementable strategy for various sectors. These regulations are often already established around schools, hospitals, and other sensitive areas, providing a familiar framework for broader adoption.

- Sample Idle Reduction Policy and Policy Guidance available, here.

- Sustainable Environment for Quality of Life hosts a Sample School Bus Anti-Idling Policy online. The policy, as well as other action steps are detailed here.

Near-port communities (communities that are within a 7-mile radius of the proposed Inland Port) and port operators have unique challenges and shared interests related to air quality that can benefit from joint problem solving. Community-port collaboration is important to address environmental justice concerns and improve quality of life for near-port communities and port workers. Collaboration with community partners can also help ports achieve better infrastructure project outcomes, increase resilience, and manage risk (EPA, 2023).

Source: U.S. EPA, Community-Port Collaboration

- Read more at EPA's Community-Port Collaboration Toolkit, here.

Success Story

The Port of Long Beach, California partners with the Long Beach Unified School District to support the innovative Academy of Global Logistics at Cabrillo High School, a four-year pathway for students interested in trade and maritime careers. The Port links with Long Beach City College and California State University, Long Beach, to offer training, study pathways for logistics careers, and professional development programs. New grant-funded demonstrations of zero-emissions and other clean port technology include workforce development and training outreach for local jobseeker (Port of Long Beach, 2019).

Ports that implement vessel scheduling, drayage operations, automated gate systems, and other PMIS can improve overall efficiency and benefit surrounding communities.

Read about Port Management Information Systems, here

RESOURCES

GENERAL RESOURCES

The EPA Ports Initiative: This initiative works with U.S. ports and local communities to improve environmental performance. The program provides technical resources, such as guides on creating port emission inventories, and toolkits and resources to promote community-port collaboration. The Ports Initiative is currently running pilot projects at four ports to provide technical assistance for community collaboration.

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Idle Reduction: This resource provides an introduction to idle reduction practices, their benefits, and resources for personal and commercial vehicles.

U.S. Environmental Protection Agency Best Clean Air Practices for Port Operations: This resource offers best practices for ports to reduce air pollution, potentially including strategies to minimize idling times from ships and cargo handling equipment.

TOOLKITS AND MODELLING APPROACHES

USDOT's Freight Logistics Optimization Works (FLOW): FLOW is a public-private partnership among industry and government to help build a forward-looking, integrated view of supply chain conditions in the U.S. The program collects purchase order information from importers in addition to logistics supply, demand, and throughput data from participants, which the Bureau of Transportation Statistics analyzes and provides a broad, daily view of the current conditions of the overall logistics network back to FLOW members.

Federal Highway Administration, Congestion Mitigation Air Quality Improvement (CMAQ) Emissions Calculator Toolkit, Diesel Idle Reduction Strategies: This tool provides air quality benefit calculations for diesel idle reduction strategies.

U.S. Environmental Protection Agency, Diesel Emissions Quantifier (DEQ): This tool allows users to estimate air pollutant emissions from various sources, including idling diesel vehicles.

Argonne National Laboratory, Vehicle Idle Reduction Savings Worksheet: This downloadable spreadsheet helps calculate potential fuel cost savings associated with reducing vehicle idling times.

U.S. Department of Energy, Petroleum Reduction Planning Tool: This online tool helps assess strategies and opportunities for reducing petroleum use across different sectors, including potential benefits from reducing vehicle idling.

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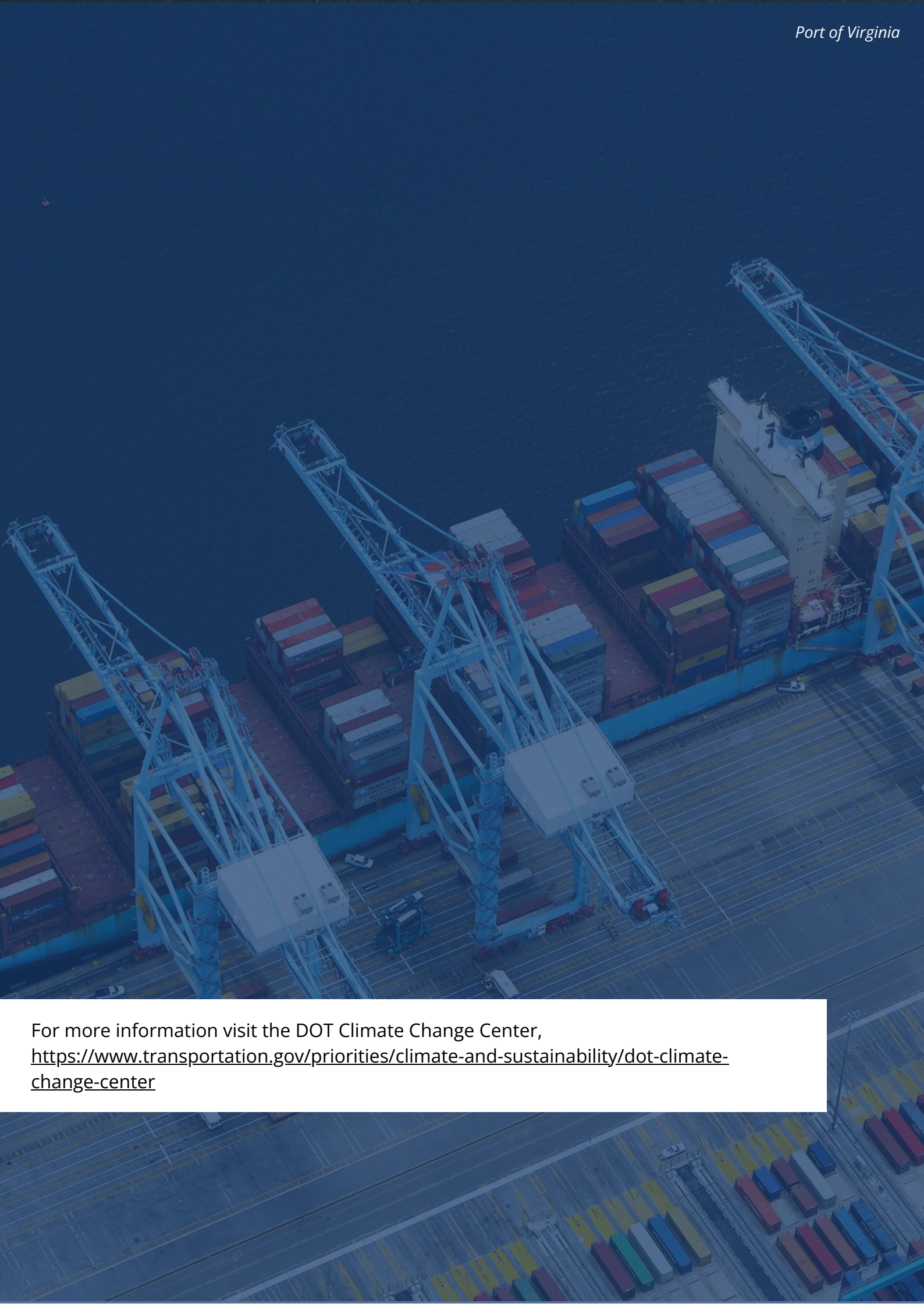

Port of Virginia

For more information visit the DOT Climate Change Center, https://www.transportation.gov/priorities/climate-and-sustainability/dot-climate-change-center