



// FREIGHT AUTOMATION'S IMPACTS ON AIR QUALITY AND HEALTH ///

Current dangers:

- Air pollution from freight transportation creates significant health problems, especially for fence-line communities.

Future threats:

- If automation proceeds without electrification and decarbonization, air pollution and related health risks will continue unabated.
- Where automation improves vehicle efficiency, pollution reductions may be negated by changes in trucking operations.

Opportunities:

- In limited scenarios, automation may slightly reduce pollution through efficiency gains, although more real-world testing is needed.
- Adopting zero-emission technologies provides much more significant pollution reductions than adopting automation alone.

“Ya hay muchos niños con cáncer, asma, problemas respiratorios, y pensar agregar otro proyecto a la comunidad es mucho.” [There’s already a lot of kids with cancer, asthma, respiratory health, lung issues, and to add another large project it is too much for our community.]

– Veronica Roman, San Bernardino community member

Summary Trends: What Freight Automation Means for Air Quality and the Health of Frontline Workers and Fence-Line Communities

“Here in the United States the main source of black carbon emissions is diesel engines. ... We’re talking about freight and transportation. But even in the freight industry, there’s also off-road diesel, which includes the port equipment and vessels. ... Everybody’s affected by diesel.”

– Dr. Robert Laumbach, Associate Professor, School of Public Health, Rutgers University

A clear and present danger of the freight transportation system is the air pollution it produces. Run largely on diesel and other petroleum-based fuels, freight contributes significantly to our country’s pollution and global climate change. Because of long-standing racial and economic segregation, air pollution and its attendant health effects particularly harm frontline workers and fence-line communities.

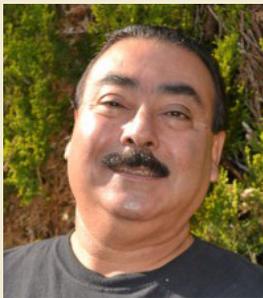
Without electrification, increased automation could lead to increased air pollution and negative health impacts.

Automating an electric engine provides substantial emission reductions, whereas automating a diesel combustion engine does not. Without electrification, automation may lead to more pollution, because operational efficiencies can allow for increased use of vehicles over the long term. In the shorter term, automation may provide some marginal reductions in air pollution for certain narrow segments of the freight transportation system. For example, some estimates have found that using automated computer-based “cruise control” or fuel management systems in freight trains offers fuel savings between 3% and 5%, with some estimates

as high as 14%.^{73,74} Similarly, there is evidence that allowing trucks to travel closer together via platooning could reduce fuel use, which, in turn, could reduce air pollution.⁷⁵ The risk, however, is that efficiency gains will lead to changes in trucking operations and increased pollution, which will outpace any pollution reductions. On its own, automating diesel-run machines in ports, warehouses, and on the roads will not make a meaningful dent in air pollution.

In contrast, with electrification, whether it happens with automation or not, air pollutants like particulate matter, nitrogen oxide, ozone precursors, and greenhouse gas emissions will decline. The benefits of any pollution reduction will directly affect the communities closest to the sources of pollution: low-income communities and communities of color.

DOES AUTOMATED EQUIPMENT MEAN EMISSION-FREE EQUIPMENT? THIS TECHNOLOGY TRACKER IS SKEPTICAL



Jesse Marquez

Jesse N. Marquez is a resident of Wilmington in Los Angeles, CA, and the founder and executive director of the Coalition for a Safe Environment. “I have lived in Wilmington all my life. Most of my 60+ years. I grew up living in East Wilmington, literally two blocks away from the Alameda Corridor, an oil refinery and two blocks is the BNSF Watson railroad yard.” He and community partners started working on freight in 2001 with a lawsuit over the China Shipping Terminal, a \$400 million project that industry stakeholders were trying to build with minimal community notice.

Jesse is also part of Trade Health and Environment Impact Project, a region-wide, community and academic collaborative formed in 2006. The collaborative’s work is to change the debate and ensure that *health* is no longer a forgotten word when discussing growth of the ports and the goods movement industry. The collaborative shared studies on the adverse health, community, and labor impacts of freight transportation going first into the Ports of Los Angeles and Long Beach and then being transported on trucks and trains to San Bernardino and Riverside County warehouses, highlighting the freight industry’s regional impacts. They also hosted several national conferences that provided policy recommendations for freight-affected communities.

“One of the specialty areas of what our organization does is researching clean alternative technologies. Zero emission freight transportation vehicles, trains, ships, cargo handling equipment and construction equipment. Of that list none of the technologies include automation.” In Jesse’s experience, zero emission technologies are automated through special custom-order designs. ■

HOW DOES FREIGHT CURRENTLY AFFECT AIR QUALITY?

Most of the freight transportation system now runs on diesel. The US Environmental Protection Agency has called the movement of freight “a major public health concern at the national, regional and community level” due to the emissions of particulate matter, nitrogen oxides, hydrocarbons, and other air toxics in diesel exhaust.⁷⁶

This pollution harms the health of children and adults alike, and is inequitably concentrated in fence-line communities.

The freight industry currently contributes greater than

- 50% of the nation's nitrogen oxides emissions
- 30% of volatile organic compound emissions
- 20% of particulate matter (PM) emissions⁷⁷

“We live where we can live and not where we want to live.”



Veronica Roman

Veronica Roman's time in southern California started in the early 1990s in Santa Monica and Inglewood. High rents pushed her east to San Bernardino. “Uno vive donde puede y no donde uno quiere.” *[We live where we can live and not where we want to live.]*

Veronica's community faces a variety of freight impacts, including two Amazon warehouses, the Burlington Northern Santa Fe (BNSF) Railyard, an airport, and freeways. “Yo creo que aquí tenemos un poco de todo como, ahora sí como un tipo ensalada, pero las bodegas están creciendo muchísimo aquí en San Bernardino. Hay mucha, mucha bodega...y ahora ya están al lado de las escuelas y hogares.” *[I think we have a little bit of everything here, it's like a type of salad [you can pick and choose from all these freight facilities], but the warehouses are growing so much here in San Bernardino. There are many, many warehouses...and now they are next to schools and homes.]* According to the American Lung Association's State of the Air report, San Bernardino County received failing grades for its ozone and PM levels.⁷⁸

Veronica previously worked as a community organizer with the Center for Community Action and Environmental Justice (CCA EJ). They did a truck count right outside the railyard where the streets have only one lane each way. They counted 500 trucks at one intersection in 1 hour. There are schools close to that railyard; CCA EJ did a study with Loma Linda University that found higher levels of asthma for the kids in the area due to the pollution. Her oldest daughter has a 5-year-old son with asthma. “Ya hay muchos niños con cáncer, asma, problemas respiratorios, y pensar agregar otro proyecto a la comunidad es mucho.” *[There's already a lot of kids with cancer, asthma, respiratory health, lung issues, and to add another large project it is too much for our community.]* ■

A Closer Look: Sector-Specific Examples

Zero-emission electrification can improve air quality whether it's coupled with automation or not.

The clearest way to improve air quality is through electrification. Where electrification happens, with or without automation, the pollution reductions can be impressive, though combining automation and electrification can come with other job-related consequences, which we discuss below.

Take the LBCT at the Port of Long Beach in southern California. Unlike the other 21 docks at the port, this one is highly automated, with self-driving vehicles and large stacking cranes controlled remotely by less staff than used for traditional cranes. Critically, this equipment is zero-emission. As a result, the terminal “emits 85 percent less diesel soot, 58 percent less nitrogen oxide (a component of smog), and 33 percent less carbon dioxide than a traditional dock at the ports.”⁴⁰ In this case, it's not the automation that created reductions in pollution, it was the decision to automate using zero-emission equipment.

“You can upgrade these machines, that the longshoremen are operating, to clean air, but they can still be controlled, or manned, by a human. ... What they're doing is upgrading these machines to clean air—which is great—but they're also making them unmanned. Why can't they upgrade them to clean air and still keep them manned?”

– John Bagakis, San Pedro small business owner

Although the decision to couple automation with electrification at the LBCT resulted in air quality improvements, it also resulted in job losses. By one estimate, two-thirds of the high-paying jobs at the LBCT disappeared because of automation.⁴⁰ Changes to employment, and the subsequent health effects, due to automation is a critical dynamic to understand. See the section *Freight Automation's Impacts on the Economic Security, Health, and Safety for Frontline Workers* for more information. ■

Automation that improves fuel efficiency provides limited air pollution reductions.

Where automation happens without electrification, air quality can improve in limited contexts. For example, using automated, computer-based “cruise control” or fuel management systems in freight trains offers fuel savings between 3% and 5%, with some estimates as high as 14%.^{73,74}

Current automation trends strongly suggest we'll see more trucks platooning in the near future. By making braking and acceleration smoother and reducing drag-platooning, configurations offer a more efficient use of fuel, which cuts down on the quantity of pollutants released. On the basis of results of demonstration projects and tests, researchers estimate that platooning can create fuel savings of 4% to 15%.^{15,75} Researchers have estimated that as fuel consumption goes down, diesel-related air pollution will also decrease.⁷⁵ This is an area in need of more research to better understand the nature of the relationship on platooning and reduction in air toxics.

Nonplatooning automation technologies may also improve fuel efficiency. In some tests, applications such as predictive cruise control and eco-driving feedback systems have shown modest fuel improvements in the 2% to 5% range, although a few were as high as 11%.¹⁵

With automation, trucking operation changes may negate air pollution–reduction gains.

An important dynamic that may potentially undermine air quality improvement is the degree to which any pollution reductions are outweighed by changes to trucking operations, including the increased presence or use of trucks. One risk is that trucks may travel additional miles by “going out of the way to create a truck platoon [which] could undermine the fuel savings and environmental benefits.”¹⁵ In addition, “If collision mitigation systems and higher levels of truck automation improve safety to the point that policymakers and the public accept faster highway travel, this could pose a risk to long-haul fuel economy as driving faster uses more fuel”¹⁵—a risk that, in turn, would endanger any air pollution reductions. Finally, evidence suggests that “as platooning technology enables safe operation at close following distances, more efficient use of road space could result.”¹⁵ That additional road capacity could then potentially induce demand, leading to increased truck traffic and pollution, like how building bigger roads actually increases traffic by making it easier for people to take more trips. “Businesses that rely on roads will swoop into cities with many of them, bringing trucking and shipments.”⁷⁹

Even as trucking's share of total freight tonnage will decrease slightly, the American Trucking Associations estimates tonnage will continue to grow over the next decade.⁸⁰ Such growth could result in more trucks on the road. Depending on the number of trucks and the air pollution they produce, gains from automation-related fuel efficiencies could be more limited or canceled. Furthermore, even if the increasing number of trucks run on cleaner engines, air pollution could still increase from brake dust and tire wear—major contributors to PM pollution. Overall, this is an area that warrants far more study.

How Freight Automation's Impacts on Air Pollution Will Affect Health and Equity

Diesel pollution is a public health risk.

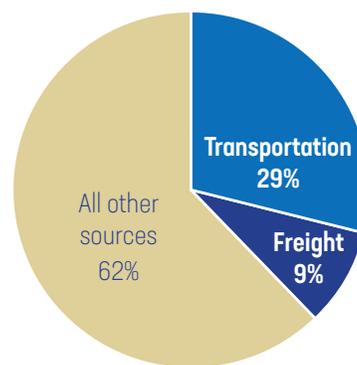
Independent of automation, diesel pollution *currently* is a clear public health risk with considerable impacts. Diesel exhaust includes:

- **Black carbon or soot**, which is associated with respiratory and cardiovascular problems, low birth rates and cancer.⁸¹
- **Organic substances**, including benzene, formaldehyde, and acetaldehyde, which are carcinogenic⁸²
- **Volatile organic compounds**, which can cause cancer, damage to the central nervous system and organs, and, when inhaled, can create difficulty breathing, cause nausea, and irritate the eyes, nose, and throat⁸³
- **Nitrogen oxides**, which contribute to ground-level ozone that reduces lung capacity and has been linked to increased hospital admissions for respiratory problems and asthma⁸⁴
- **Particulate matter**, which comprises very small particles that can cause cancer, heart problems, respiratory issues, cardiopulmonary- and lung cancer-related deaths, premature death, and can trigger asthma attacks.⁸⁴⁻⁸⁷ Exposure to fine PM is estimated to be responsible for three to four million deaths from air pollution worldwide.⁸⁸ Particulate matter includes fine particulate matter (PM2.5) and coarse particulate matter (PM10).⁸⁵

Although all of these pollutants are important, PM stands out: nearly two-thirds of all PM emissions from US transportation sources comes from diesel-powered vehicles and equipment.⁸⁹ In addition to being released through diesel exhaust, it's also created by nonexhaust sources like dust from tire, clutch, and brake wear on the roads.⁹⁰

Freight transportation pollution also contributes significantly to climate change. After the production of electricity, the transportation industry is the second largest producer of climate change-inducing greenhouse gas emissions in the United States.⁹¹ Almost one-third (29%) of all emissions come from transportation⁹² and 9% of total greenhouse gas emissions are from the freight industry.⁷⁷

Sources of Greenhouse Gas Emissions in the United States



Air pollution disproportionately affects fence-line communities.

Because of their proximity to freight infrastructure, low-income communities and communities of color are disproportionately burdened by air pollution from PM-producing facilities.⁹³ Across the country, communities of color are also disproportionately affected by the harms of transportation-related pollution.^{88,94} For example, Black, Latinx, and Asian American Californians are exposed to much higher rates of vehicle-produced PM than are White Californians, and people living in households with low incomes (<\$20,000/year) had 25% more PM exposure than did the highest-income groups.⁹⁵ In the Northeast and Mid-Atlantic, on average, Latinx residents are exposed to 75% higher air pollution; Asian American residents are exposed to 73% higher air pollution than White residents; and Black residents are exposed to 61% higher air pollution from vehicles than are White residents.⁸⁸

Racial and economic segregation is associated with greater air pollution exposure and health inequities.

Although the Civil Rights Act of 1968 made housing discrimination based on race illegal, segregation continues today; housing discrimination affects people's health and is a fundamental cause of health inequities.⁹⁶ Researchers have found that people who live in racially segregated areas have higher exposures to cancer-causing ambient air toxics.⁹⁷ Another study found that in areas that were historically redlined (i.e., neighborhoods where there was systemic denial of mortgage loans to people of color), people had much higher rates of emergency room visits for asthma attacks.⁹⁸

For health and equity, electrification is critical, whether it happens with automation or not.

If the freight sector is deliberately electrified, be it in combination with automation or on its own, the air quality and related health improvements could be meaningful, particularly for frontline workers and fence-line communities already facing an inequitable burden of air pollution. Smaller improvements may be possible without electrification where automation allows for more efficient fuel use. However, if freight automation is *not* simultaneously coupled with electrification, we are likely to see a continuation of the high and inequitable levels of air pollution, along with all the health risks they bring, in communities most burdened by the freight system.

As detailed above, people living close to air pollution already face negative health consequences. In addition, for some workers in the freight system, high levels of air pollution can be a burden that adds to other automation-related stresses, such as increased pressure to meet productivity quotas. According to Roberto Clack, associate director at Warehouse



“When [there are] changes [and] improvement in air quality, there’s improvement in health.”

– Dr. Robert Laumbach, Associate Professor
Rutgers University School of Public Health

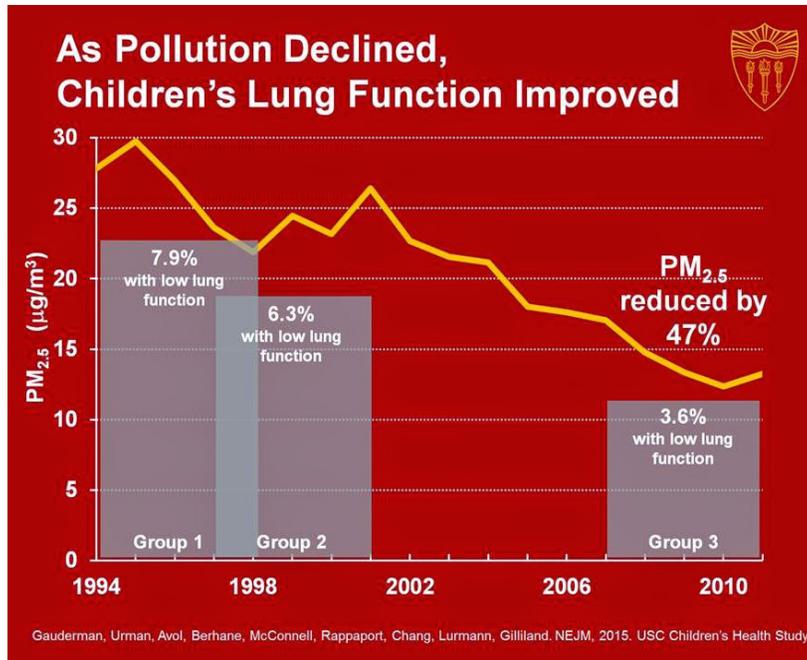
Workers for Justice, “Air quality is an issue. And that has an impact on respiratory [health] and hypertension. Are you creating a situation where people are working harder than ever [due to automation], and the air quality is bad? I could imagine automation even contributing to something like that.”

Better health depends on cleaner air.

According to Dr. Robert Laumbach, Associate Professor at Rutgers University’s School of Public Health, “When [there are] changes [and] improvement in air quality, there’s improvement in health.” For instance, studies show that children who grow up in more polluted areas face increased risk of reduced lung development.⁹⁹ One study found that living close to a railyard increases the number of asthma emergency room visits by children, and asthma risks were higher for children living near the top five pollution-emitting rail yards.¹⁰⁰ Asthma episodes in children cause sick days, lost school days, and lost learning.¹⁴³ Studies have also found that living in areas with high levels of PM was associated with an increased risk of preterm birth.¹⁰¹⁻¹⁰³ Again, these impacts are not equally distributed: low-income children and children of color face significantly greater disease burden as a result of exposure to air pollution.

In this context, the story of Maria is both moving and unsurprising. Originally from Mexico, Maria moved to San Bernardino about 20 years ago and recently started working at the Amazon Fulfillment Center. This Amazon facility, combined with other warehouses, industrial and commercial facilities, a railyard, and a freeway, have resulted in high levels of air pollution in San Bernardino. Maria’s two daughters have asthma, as do many of her coworkers. “La realidad es que hay una necesidad de trabajo y por el otro lado es lo que te está perjudicando, la salud tuya y de tu familia.” [*The reality is that there is a need to work and on the other hand the work is hurting you, your health, and your family.*]

Maria’s daughters are now 12 and 14 years old. The schools they attend are close to freeways and the railyard, so there is often a lot of truck traffic. There is also a community center and park with a daycare facility right next to the railyard. Though the school did install air filters in the classrooms, students still go outside for recess. By her house, there is a ban on trucks passing through, but it’s not enforced. Maria is also a school crossing guard and has



USC Environmental Health Centers

noted an increase of trucks in her neighborhood. She has participated in truck counts with a community organizer from the Center for Community Action and Environmental Justice, and was shocked at the findings: “Me vine sorprendidísima que vine contándole a mi esposo y más preocupación me dio mis hijas que como te dije tienen asma y yo tengo alergias. Pues que triste que en una hora hayamos contando más de 600 camiones por casas y escuelas.” [I left there astonished that I came home telling my husband and I'm more worried about my daughters with asthma and I have allergies. It is so sad that we counted 600 trucks in one hour so close to homes and schools.]

When Maria's older daughter was about 1 year old, she was hospitalized for 4 days because of her asthma. Maria links her children's asthma to the pollution exposure in San Bernardino. She considered moving to Fresno, CA, thinking there was better air quality given the number of farms. But her research showed that, in part due to freight transportation, the air quality was just as bad there and in other places like Long Beach, CA, where she also considered moving. Ultimately, Maria came to realize “la solución no es moverme, la solución es que hagan algo para que aquí no haya tanta contaminación.” [The solution isn't to move, the solution is to do something so that there isn't as much pollution here.]

Maria doesn't see a choice between jobs and the environment. “Yo se y entiendo que nosotros necesitamos esos camiones porque nos traen los bienes a nuestra ciudad o los llevan. Eso es indispensable, lo entiendo. Pero pueden modificar y hacerlos eléctricos para que no contaminen más.” [I know and understand that we need these trucks because they bring us goods or take them. This is indispensable, I understand. But they can modify and make the trucks electric so they don't pollute more.]

If freight automation is **not** simultaneously coupled with electrification, then we'll likely see high and inequitable air pollution in fence-line communities.

Electrification, with or without automation, will help prevent climate change.

Electrification, whether it happens in conjunction with automation or not, is necessary to halt the increase in and consequences of climate change. Left unchecked, climate change will cause significant harms for communities across the country, especially those who are already most vulnerable including “the poor, the elderly, those already in poor health, the disabled, and indigenous populations.”¹⁰⁴ These harms include more frequent and intense wildfires, which increase levels of health-harming PM in the air¹⁰⁵; longer and more frequent heat waves; and greater risks from flooding and intense storms.¹⁰⁴ Coupling automation with electrification can make a positive difference with regard to climate change. For example, electric trucks have zero tailpipe emissions, and switching to electric semi-trucks and school buses can cut global warming emissions by half.⁹²

AREAS FOR EXPLORATION

-  What amount of pollution can be reduced with the widespread use of platooning?
-  To what extent will the increased use of platooning result in more trucks on the road, which, in turn, could counteract any pollution reductions?
-  Will the increased use of platooning result in faster-traveling trucks, which risks fuel and pollution reductions? ■