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Transportation in a Changing Climate: Innovating to Create Resilient, Low-Carbon Systems

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Innovating to Create Resilient, Low-Carbon Systems

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The climate is changing rapidly, bringing new temperature highs and weather extremes and affecting every individual, community, and sector of society—including transportation. Although, at times, climate change may feel like an insurmountable challenge, humanity is resilient and innovative. Transportation ultimately is about people: connecting people to places, to goods and services, and to each other. Because of its central role in the functioning of society, the transportation system—including its infrastructure, networks, and workforce—is an essential part of addressing and responding to climate change.

This article discusses challenges and opportunities for building resilient and low-carbon transportation solutions in the United States.

The Challenge of Climate Change

Each year brings more changes and extremes in storms, floods, wildfires, and other climate-related impacts. January through May 2020 brought heavy rainfall and flooding to much of the United States, leading to road damage and closures, a

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U.S. Coast Guard and volunteer boats bring Hurricane Katrina evacuees to dry land in New Orleans, Louisiana, in 2005. In the years since the devastating storm, climate change has only made hurricanes more frequent.

Above: All lanes along this stretch of SH-288 in Houston, Texas, flooded during Hurricane Harvey in 2017. Damage from stronger and more unpredictable hurricanes is among the many effects of climate change on transportation infrastructure.

Photo: Infrogmation of New Orleans

The New Orleans City-Assisted Evacuation Program set up designated hurricane or disaster evacuation pickup spots, such as this one on Read Road.

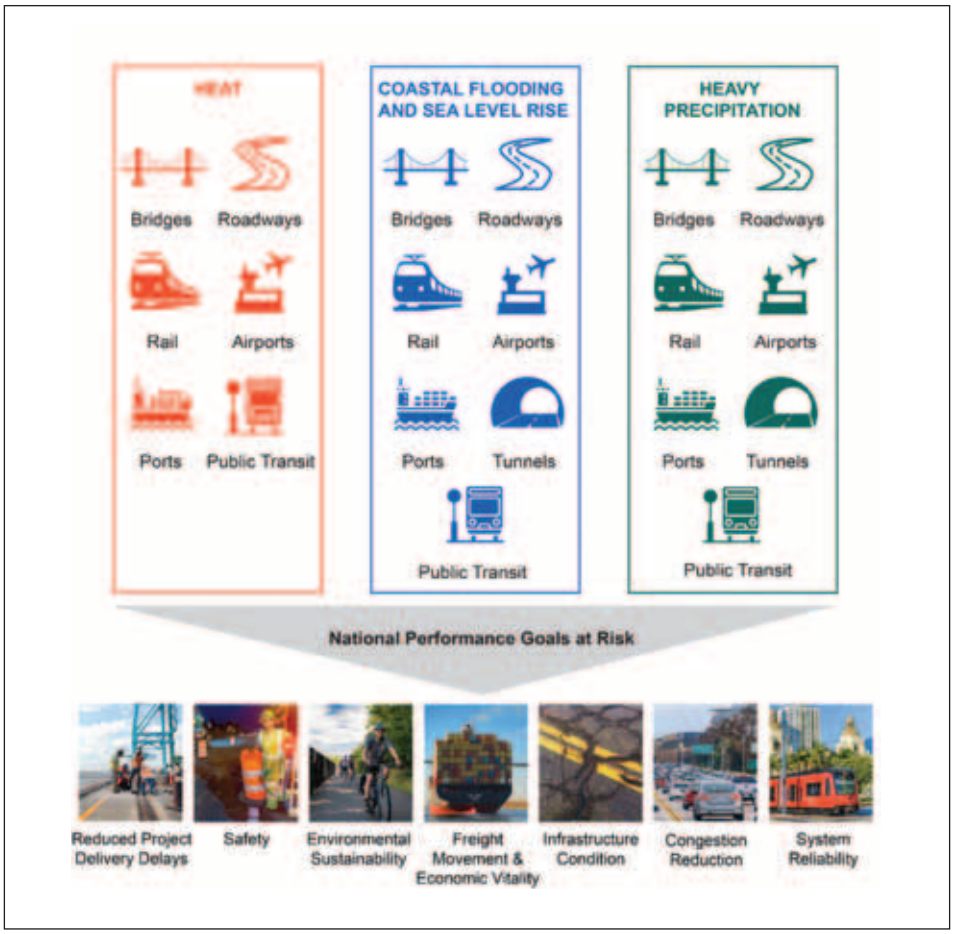

FIGURE 1 Climate change transportation vulnerabilities. (Source: Fourth National Climate Assessment, 2018.)

train derailment, and other transportation system impacts (*1*). Temperature averages are shifting as well: globally, January 2020 was the warmest January ever recorded, and July 2019 was the hottest *month* ever recorded (*2*–*3*). The combined effects of aging infrastructure, system complexity, and cross-sector interdependencies make it all the more important to begin planning for and addressing climate-related risks.

The 2018 National Climate Assessment found that, in addition to the physical risks to infrastructure from increasing temperatures and extremes, climate change will cause or exacerbate transportation disruptions, resulting in societal and economic impacts (*4*; Figure 1). These impacts are especially pronounced for individuals at higher risk because of mobility limitations, preexisting health conditions, age, income, and other factors.

These varied physical, societal, economic, and cross-sectoral risks pose significant challenges for making decisions about the legal standards, design, construction, and operation and maintenance of transportation systems. Although work to understand system vulnerabilities and risks is under way at TRB and throughout the transportation field, there are constraints in applying new information in constructing and operating transportation systems.

For example, climate projections often are not translated into actionable terms for infrastructure design; additionally, agencies may struggle to justify higher upfront adaptation costs because of practical or political realities. Policy makers, researchers, engineers, communities, and other stakeholders must work together to build more resilient, low-carbon transportation solutions that foster a more sustainable, equitable, and connected society.

Building Climate-Smart Systems

The resilience and security of transportation infrastructure, networks, systems, and the workforce are of increasing concern in the context of a changing climate. Physical assets are at risk from extreme heat; flooding from precipitation, sea-level rise, and storm events; wildfires; landslides; and more. Weather extremes, rising seas, and other impacts pose challenges for system performance and management, affecting life-cycle costs of maintaining and operating infrastructure.

Risks to the transportation workforce also are of growing concern (e.g., increasing exposure to extreme heat and other dangerous outdoor conditions), highlighting just one of the many safety and public health considerations relating to climate change (*5*). Interdependencies between transportation and energy, telecommunications, healthcare, and other critical sectors bring risks of cascading failures.

Transportation resilience is a rapidly growing field. Research, planning, design, and policy have advanced significantly since

the 2008 release of *TRB Special Report 290: Potential Impacts of Climate Change on U.S. Transportation*. Some of this progress has occurred in response to federal support and incentives, such as funding for pilot projects and tools and technical assistance for vulnerability assessment and planning, or because of federal guidelines and requirements, such as the integration of resilience into long-range planning.[1] Transportation agencies work to understand vulnerabilities at the network, corridor, and asset levels and to improve resilience through changes in programming, design, and operations and maintenance practices.[2]

Other progress has been made as a result of multisectoral or governmentwide approaches, including climate change task forces, statewide adaptation plans, and laws and policies that require the consideration of climate change in decision making regarding public investments.[3] These are important steps toward incorporating climate change considerations within decision making, which is needed to foster more holistic approaches to building resilience. Still, more innovation is needed to bridge interdisciplinary gaps, center equity considerations, and consider broader landscape-scale challenges (e.g., encroaching seas, wildfire zones, and ecosystem migration) in transportation decision making.

Reducing Greenhouse Gas Emissions

Transportation also must be part of any strategy to reduce the emissions that are fueling climate change. In 2017, the transportation sector surpassed the electricity sector as the single largest source of greenhouse gas (GHG) emissions (*6*) (Figure 2). A GHG reduction strategy in the transportation sector is key to action on energy and sustainability.

To transition to a more sustainable future, policy makers at all levels must adopt policies and solutions that facilitate a rapid shift to low- and zero-emission travel. Widespread public and private investments in electric vehicle charging stations are needed, as well as incentives to develop transformational technologies in areas such as battery storage. Such efforts should be paired with policies designed to affect traveler behavior and ultimately reduce overall vehicle miles traveled, including through greater investments in transit and alternatives to single occupancy vehicles. Emissions from freight and other modes—such as aviation and marine travel—should also be addressed, including through electrification, efficiency requirements, and the use of zero- and low-carbon liquid fuels.

Electric vehicles already provide significant emissions reductions relative to petroleum-fueled vehicles—even when accounting for electricity production—and electric vehicles will become even lower-emitting over time as the power sector continues to decarbonize. State, regional, federal, and international initiatives are designed to facilitate the transition to transportation electrification. These include California's Zero-Emission Vehicles (ZEV) sales mandate for auto manufacturers; incentives for the purchase of electric vehicles (EVs); the 10-state ZEV Task Force and the international ZEV Alliance; federal policy designating and funding EV corridors; regional corridor planning [such as through the Transportation and Climate Initiative of the Northeast and Mid-Atlantic States (TCI),

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Photo: Waltarrrrr, Flickr

A haze—indicating poor air quality—hovers over Los Angeles, California. The health impacts of air pollution include increased risk of asthma, cardiovascular disease, and premature death.

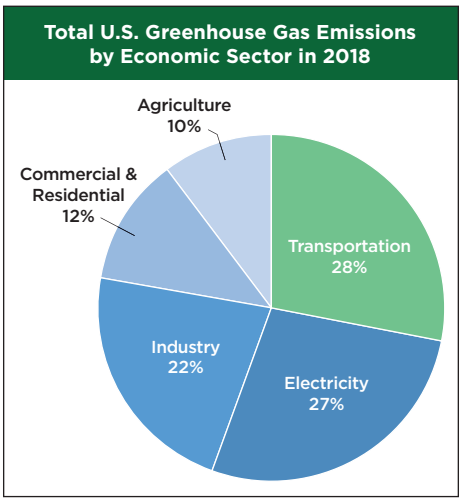

FIGURE 2 Transportation accounts for more than a quarter of U.S. GHG emissions. (Source: U.S. Environmental Protection Agency.)

[1] See, for example, a map compiled by the Federal Highway Administration of resilience pilot projects: https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/.

[2] For examples of how transportation agencies are integrating climate change considerations into assessments, planning, design, construction, and operations and maintenance, see Transportation Sector Case Studies, Adaptation Clearinghouse, Georgetown Climate Center: https://www.adaptationclearinghouse.org/sectors/transportation/case-studies-a.html.

[3] For an overview of U.S. state-by-state adaptation efforts across multiple sectors, see State and Local Adaptation Plans, Georgetown Climate Center: https://www.georgetownclimate.org/adaptation/plans.html.

Photo: Oregon DOT

As part of the West Coast Electric Highway, an EV corridor stretching from Canada to Mexico, Oregon Department of Transportation offers charging stations for EV drivers.

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the West Coast Electric Highway, and the Regional Electric Vehicle Plan for the West]; and in-state efforts to increase EV charging infrastructure through direct investments, local development requirements, and more. Additional and expanded policy action is needed to meet science-based decarbonization targets, however.

New approaches in funding and investment in innovative strategies include multistate coalitions like TCI, which is developing regional market-based approaches to reduce carbon and other air pollution through investment in low-carbon transportation alternatives (*7*). Some states are exploring mileage-based fee options, which would fund transportation investments while offering incentives for individuals to reduce vehicle travel and opt for transit, active transportation, or other alternatives. Many cities are exploring congestion pricing options to reduce traffic, improve air quality, generate revenue, and influence travel behavior.

In addition to state and local policies, more-stringent federal fuel economy standards and greenhouse gas standards for cars and trucks are critical to reducing transportation-sector emissions. Federal vehicle standards are cost-effective and save trillions of dollars for drivers while reducing emissions. Leadership from federal and state governments could help provide stronger policy drivers and incentives for innovation. Renewed U.S. participation and leadership in the Paris Agreement and future international efforts to combat climate change would generate additional accountability and motivation for climate action in the transportation sector, in the United States and beyond.

Innovating for Resilient and Low-Carbon Transportation

Climate change is a challenge that affects all people and aspects of society. Adequate solutions will require international collaboration, public engagement, private innovation, and a whole-of-government approach.

As a sector that is critical to economies and livelihoods, transportation is an important piece of this puzzle; our systems must promote a more sustainable future and be resilient to the changes to come. We need policies that incorporate climate change considerations in decision making and practices that foster a culture promoting resilience and sustainability within government and more broadly. We also need research to advance public and private solutions that achieve multiple benefits for the environment, the economy, health, equity, and mobility.

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