Infrastructure to support a 100% zero-emission tractor-trailer fleet in the United States by 2040

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WEBINAR
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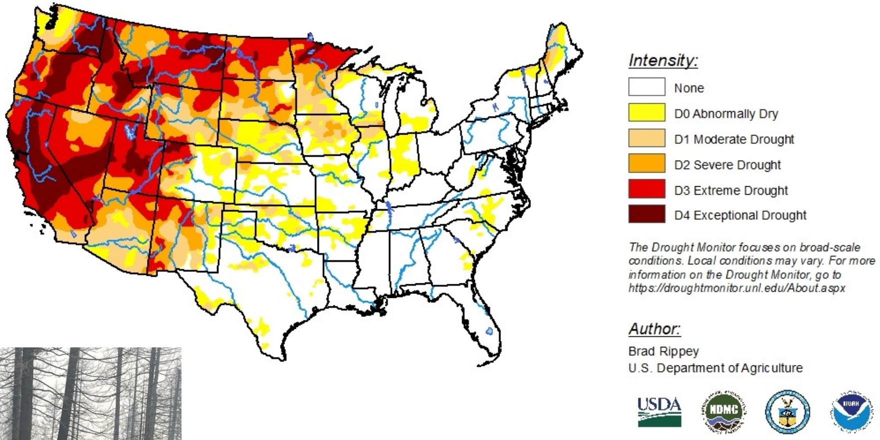
Introduction

More Intense Climate Change Events

2021 Louisiana Floods

Source: https://www.weather.gov/safety/flood-states-la

20-Year Ongoing West Coast Drought



Source: https://droughtmonitor.unl.edu/CurrentMap.aspx

2021 Dixie Fire

Source: https://www.nps.gov/lavo/learn/news/juniper-lake-cabins-destroyed-dixie.htm

Climate Impacts of Transportation

- Transport releases more GHGs than any other source in the US
- Tractor-trailers are ~13% of the MHD fleet
- Tractor trailers produce ~60% of MHD emissions

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Five Key Actions to Accelerate Zero Emission Trucks and Buses

- Phase-in targets
- Zero Emission Performance Requirements
- Fiscal incentives
- Fueling and charging infrastructure
- Purchase requirements

Approach and Key Findings

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What's the scale of the rollout until 2050?

2.4 million zero-emission tractor-trailers on the road

2.5 million charging points and almost 7,000 H_2 stations

Over 200,000 of those must be public chargers with >1 MW

Over 250,000 public chargers at truck stops (100 kW)

Almost $250 billion of cumulative investment needed

Half of it for **publicly accessible** infrastructure

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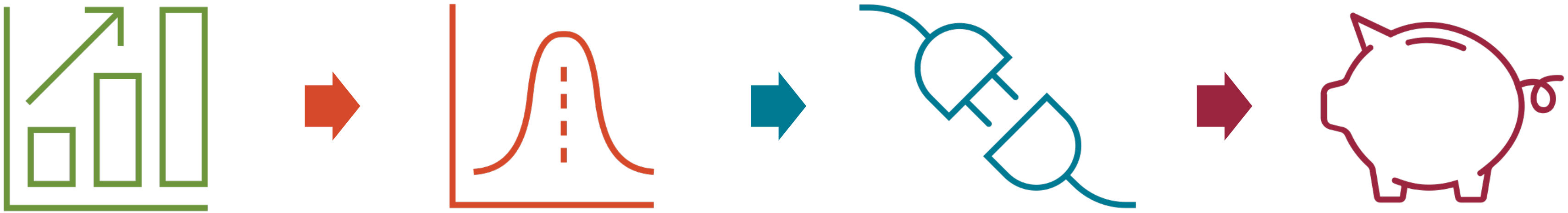
Modeling Framework



ZET deployment
- 2040 U.S. ICE phase-out
- 2030-35 in California
- Powertrain split

ZET activity
- Energy consumption modeling
- Daily VMT distribution
- Daily energy consumption

chargers / H2 stations
- Is overnight sufficient?
- What fast charging power is needed?
- Utilization rate

Cost of chargers
- Hardware & installation
- Learning effects
- Charger lifetime

Powertrain mix of the future fleet

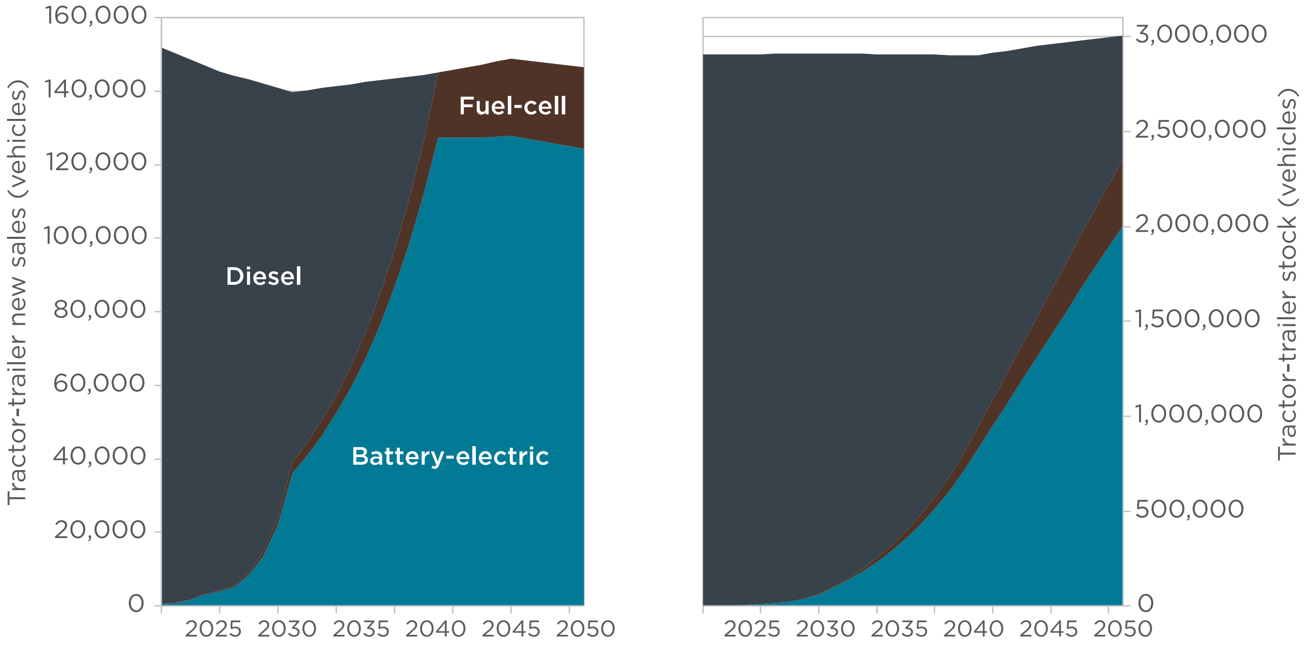
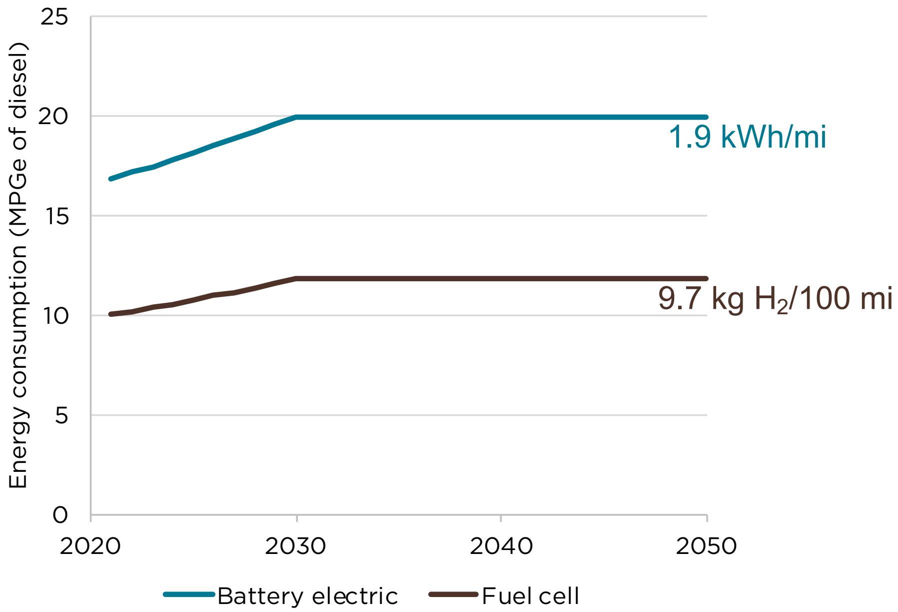


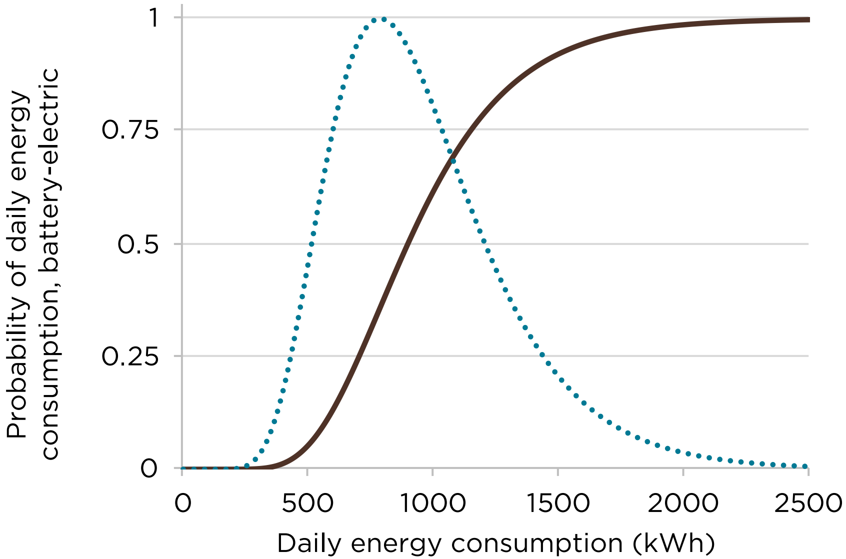
Figure 1. U.S. tractor-trailer sales and stock, assuming a transition to 100% zero-emission vehicle sales by 2040

Fuel-cells are deemed necessary for trucks traveling more than 650 miles a day.

Since both battery and fuel-cell truck technologies continue to evolve, we did a sensitivity analysis on this assumption

Energy consumption modeling





More than 90% of use cases are projected to need publicly accessible infrastructure, based on the energy consumption modeling. Private depot charging is fundamental, but not sufficient

What infrastructure did we model?

Table 3. Assumptions used in the analysis of the infrastructure requirements for battery electric heavy-duty tractor-trailers.

Type of charger	Power (kW)		Charger cost (USD)		Installation costs (USD/kW)	Utilization (vehicles per day)		Charging duration (h)
	Average	Nominal	2021	2050	2021–2050	2021	2050	
Overnight	85	100	49,000	27,300	240	1 (depot) 0.1 (public)	1 (depot) 1.5 (public)	7
Fast	300	350	134,500	76,300	129	1	12	0.5
Megawatt	850	1000	336,000	190,800	77	1	12	0.5

Table 4. Assumptions used in the analysis of the infrastructure requirements for fuel cell trucks

Capacity of hydrogen refueling station	4,800 kg/day
Utilization rate, 2021/2050	10%/75% of capacity
Cost of hydrogen refueling station, 2021	$6,000,000
Cost of hydrogen refueling station, 2050	$3,300,000

Infrastructure needs until 2050

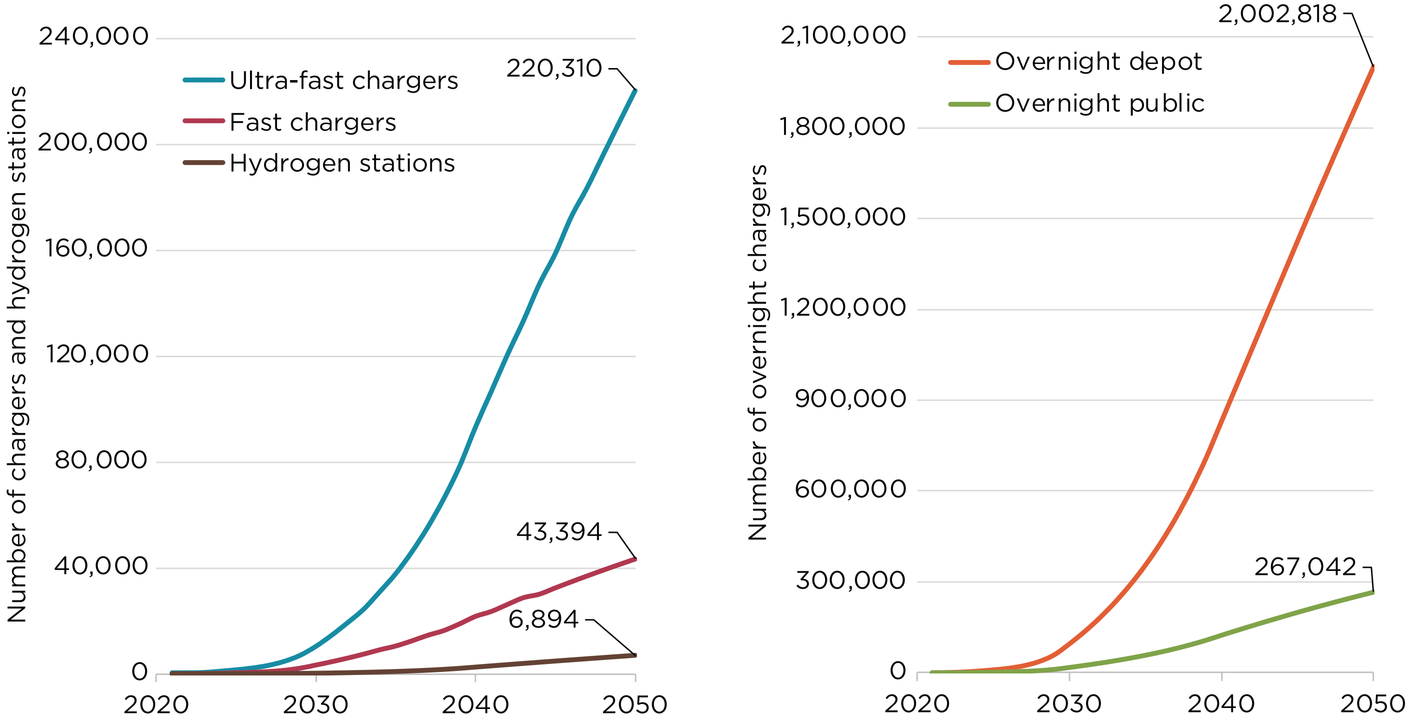


Figure 2. Number of chargers and hydrogen refueling stations needed to support 100% zero-emission tractor-trailer sales from 2040

Distribution of needed investment in publicly accessible infrastructure

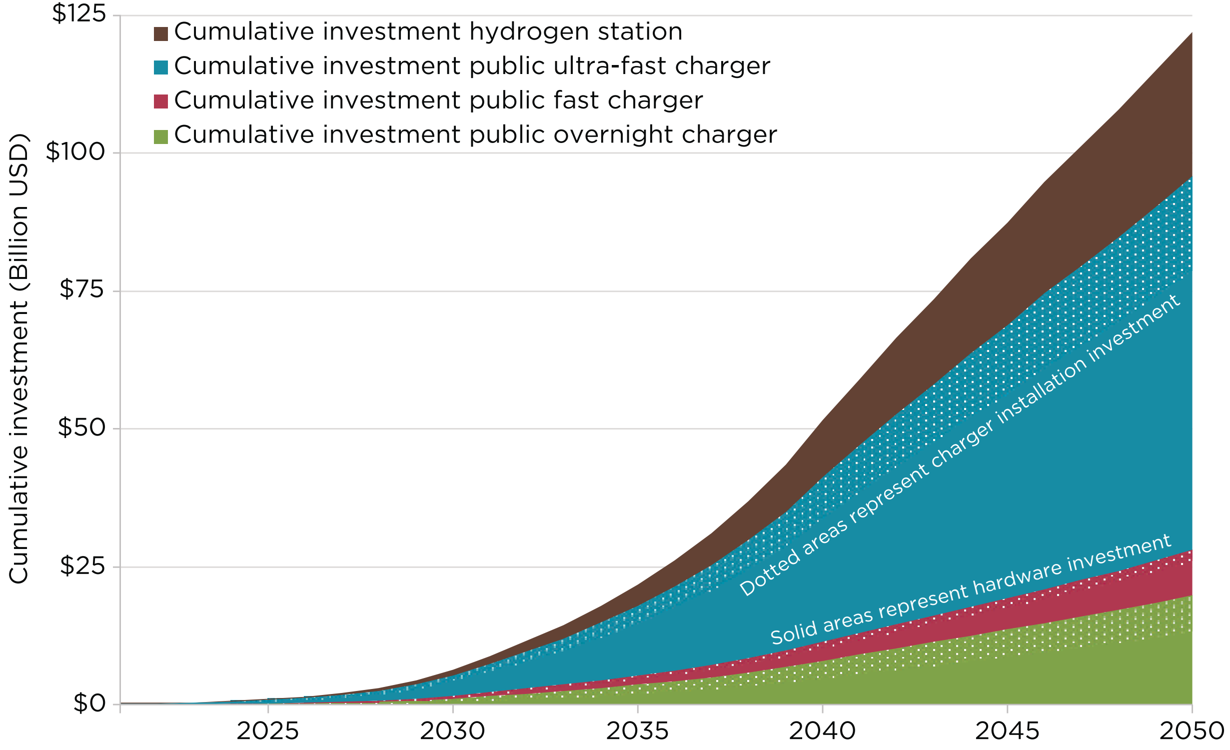
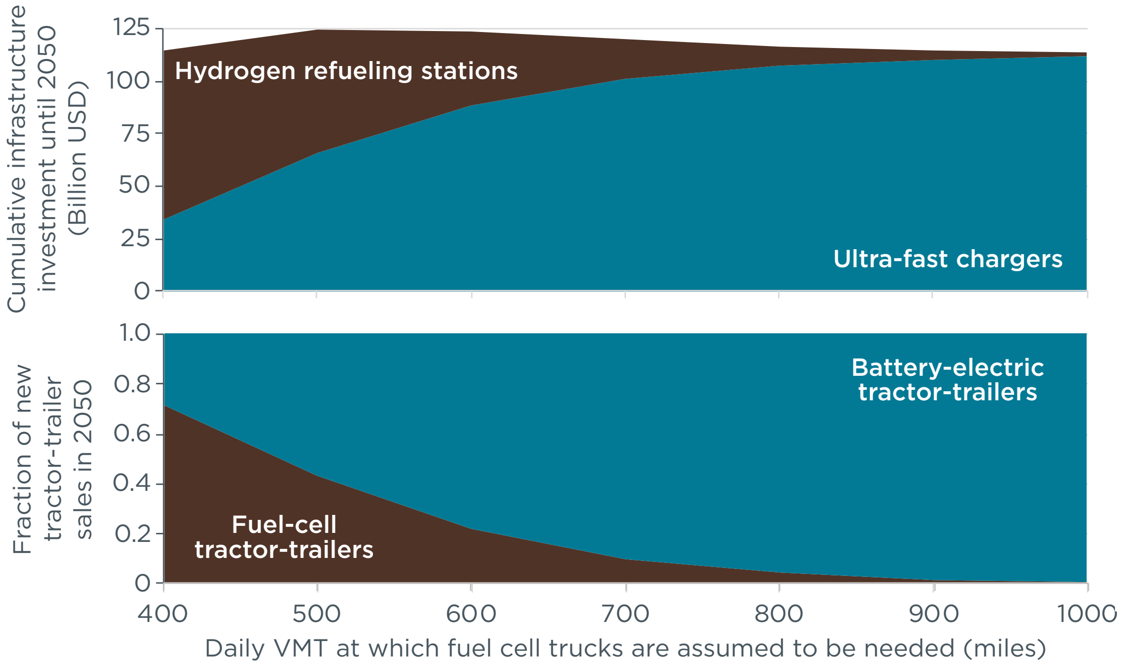


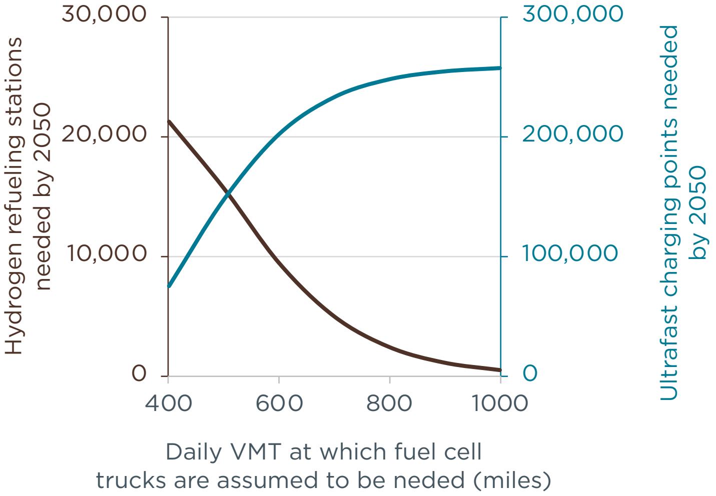
Figure 3. Cumulative investment needed to provide publicly accessible infrastructure to support the U.S. zero-emission tractor-trailer fleet, by infrastructure and expenditure type, from 2020 to 2050

Ultra fast, 1 megawatt chargers, represent the bulk of the investments.

Between $60 and $80 billion (depending on fuel cell uptake), until 2050

There is low sensitivity to H_2 deployment





Timeline of investment

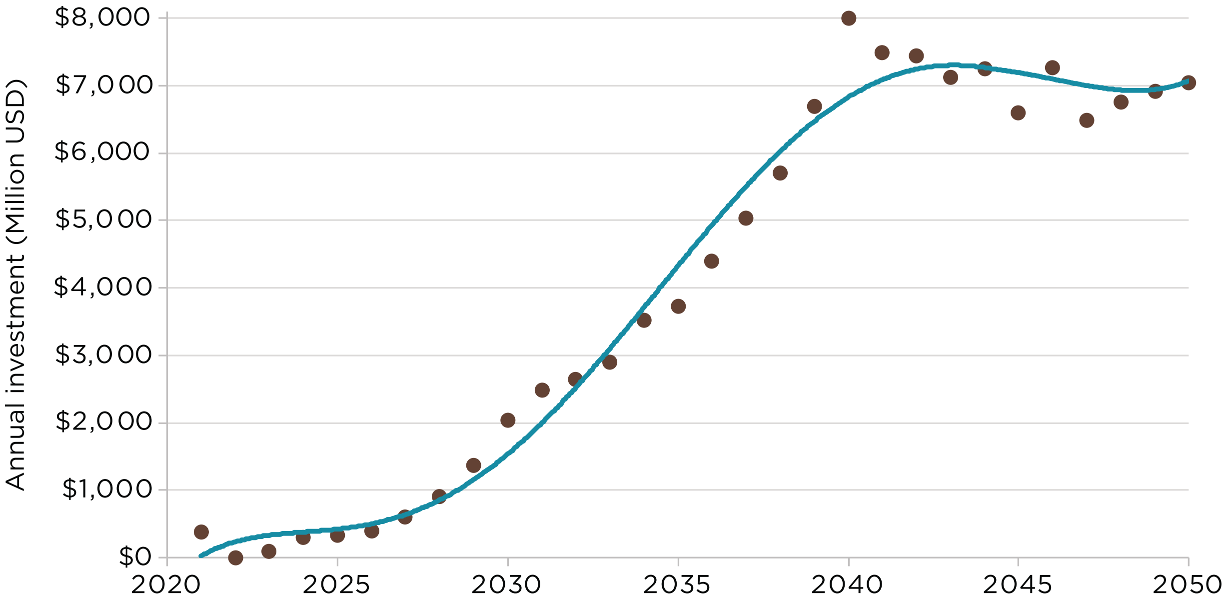


Figure 4. Total annual investments in publicly accessible charging and refueling infrastructure for zero-emission tractor-trailers

An average investment of $4 billion per year from 2021 to 2050 will be required on publicly accessible infrastructure.

Most significant investments after 2038, at an average of of $7 billion until 2050.

Summary: Fleet of zero-emission trucks

Table 5. Infrastructure needs of a 100% zero-emission tractor-trailer fleet in the United States

	2030	2040	2050
Size of zero-emission tractor-trailer fleet	103,000	950,000	2.4 million
Share of combustion engine tractor-trailers	96.4%	67%	21%
Share of battery-electric tractor-trailers	3.3%	29%	67%
Share of fuel-cell tractor-trailers	0.3%	4%	12%

The national fleet of Class 7 and Class 8 tractor-trailers is projected to grow by 3.5% in the next 30 years, totaling around 3 million tractor-trailers in 2050.

Assuming a transition to 100% zero-emission vehicle sales by 2040, by 2050, the 2.4 million zero-emission tractor-trailers operating on U.S. roads will constitute 79% of the entire tractor-trailer fleet.

Summary: Scale of infrastructure rollout

	2030	2040	2050
Overnight private chargers (100 kW)	95,000	830,000	2 million
Overnight public chargers (100 kW)	18,000	125,000	267,000
Fast chargers (350 kW)	3,200	22,000	43,000
Ultra-fast chargers (1 MW)	10,500	93,000	220,000
Hydrogen refueling stations (4,800 kg/day)	220	2,500	6,900

2.5 million charging points and almost 7,000 H_2 stations will be required by 2050.

10% will be publicly accessible fast charging points with more than 350 kW.

11% will be publicly accessible overnight depot charging with more than 100 kW.

Overnight depot charging will provide the remaining charging opportunities.

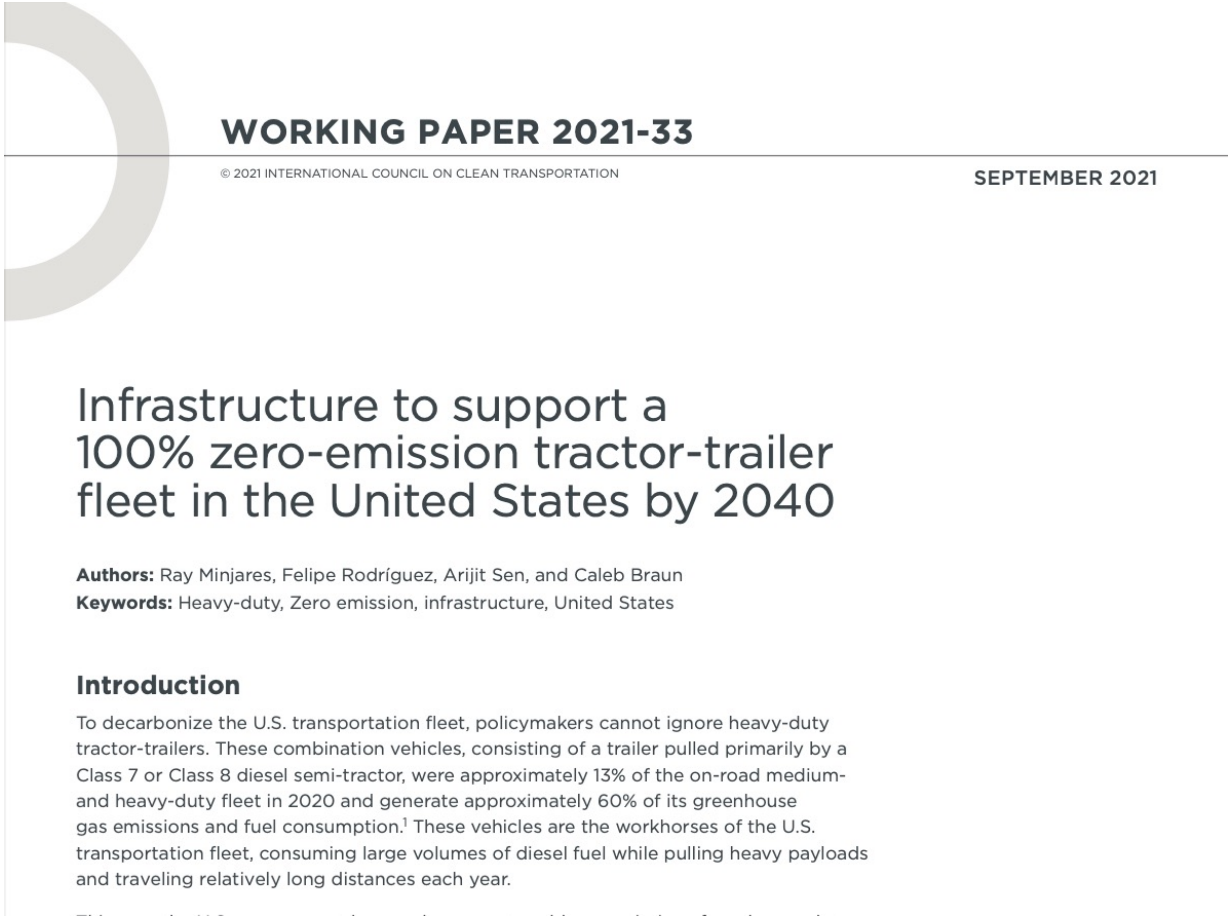
Summary: Scale of investment

	2030	2040	2050
Median annual investment in publicly accessible infrastructure over the previous decade	$0.4 billion	$4 billion	$7 billion
Cumulative investment in publicly accessible infrastructure from 2021	$6 billion	$52 billion	$122 billion
Cumulative investment in private overnight depot chargers from 2021	$6 billion	$49 billion	$116 billion
Total cumulative public and private investment	$12 billion	$101 billion	$238 billion

The cumulative investment in **publicly accessible infrastructure** until 2050 is estimated at $122 billion.

The cumulative **private investment in this limited-access depot charging** is estimated at $116 billion through 2050.

Find out more



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Introduction

To decarbonize the U.S. transportation fleet, policymakers cannot ignore heavy-duty tractor-trailers. These combination vehicles, consisting of a trailer pulled primarily by a Class 7 or Class 8 diesel semi-tractor, were approximately 13% of the on-road medium- and heavy-duty fleet in 2020 and generate approximately 60% of its greenhouse gas emissions and fuel consumption.[1] These vehicles are the workhorses of the U.S. transportation fleet, consuming large volumes of diesel fuel while pulling heavy payloads and traveling relatively long distances each year.

Minjares, Ray, Felipe Rodriguez, Arijit Sen, and Caleb Braun. 2021. "Infrastructure to Support a 100% Zero-Emission Tractor-Trailer Fleet in the United States by 2040." *International Council on Clean Transportation*, September. https://theicct.org/publications/ze-tractor-trailer-fleet-us-hdvs-sept21.

THANK YOU

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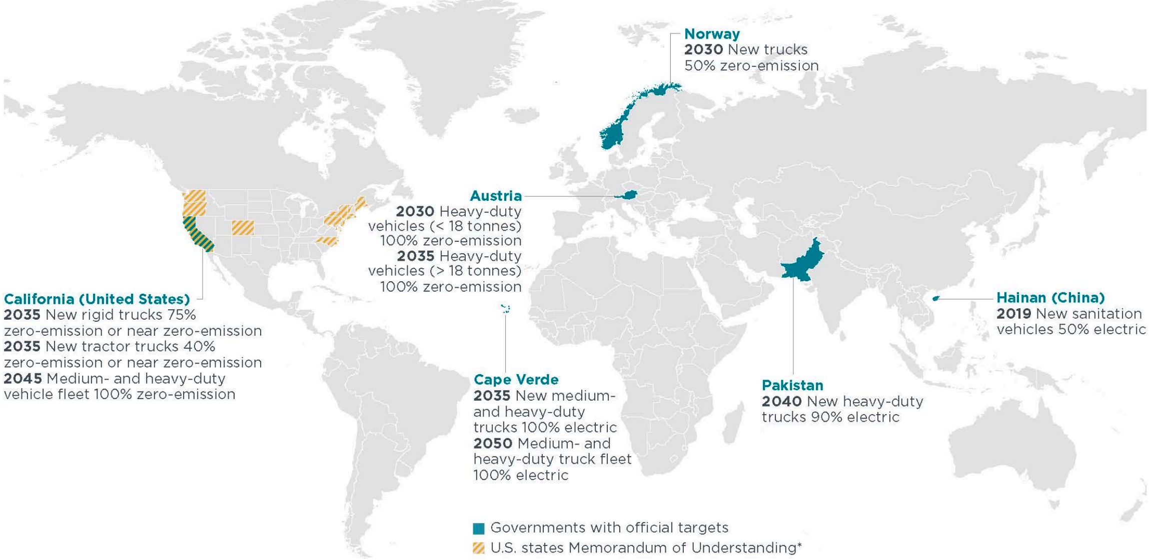
The Zero Emissions Decarbonization Path

Zero Emission HDV Sales

~100,000 in China (2019)
~28,000 in Europe (2020)
~300 in United States (2020)

Governments with targets toward phasing out sales of internal combustion engine trucks by a certain date (Status: August 2021)



U.S. states Memorandum of Understanding (MoU)
California, Colorado, Connecticut, Hawaii, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont and Washington and the District of Columbia
2030 New medium- and heavy-duty vehicles 30% zero-emission
2050 New medium- and heavy-duty vehicles 100% zero-emission

Note: Governments with an at least 40% new truck sales target.
* Not necessarily yet reflected in an official national/state policy document such as a climate or transport strategy/plan, in a law, or in a similar framework.

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