Electric Truck Guidance Report Series

High-Potential Regions for Electric Truck Deployments:

Technical Appendix

NORTH AMERICAN COUNCIL FOR FREIGHT EFFICIENCY

IN PARTNERSHIP WITH

ROCKY MOUNTAIN INSTITUTE

Table of Contents

Introduction

Fully electric trucks, often referred to as commercial battery electric trucks, are reaching wider-scale consideration as truck, engine, and other component makers are developing the systems that will support such vehicles. Battery and power-electronic development has progressed to make these trucks viable in certain applications. These trucks will have many benefits (more renewable energy, simpler design, etc.), but come with challenges (need for new infrastructure, development investments, etc.).

To date, the North American Council for Freight Efficiency (NACFE) and Rocky Mountain Institute (RMI) have published four Guidance Reports on a range of topics related to commercial battery electric vehicles and continue to study developments in this rapidly changing segment of the trucking industry.

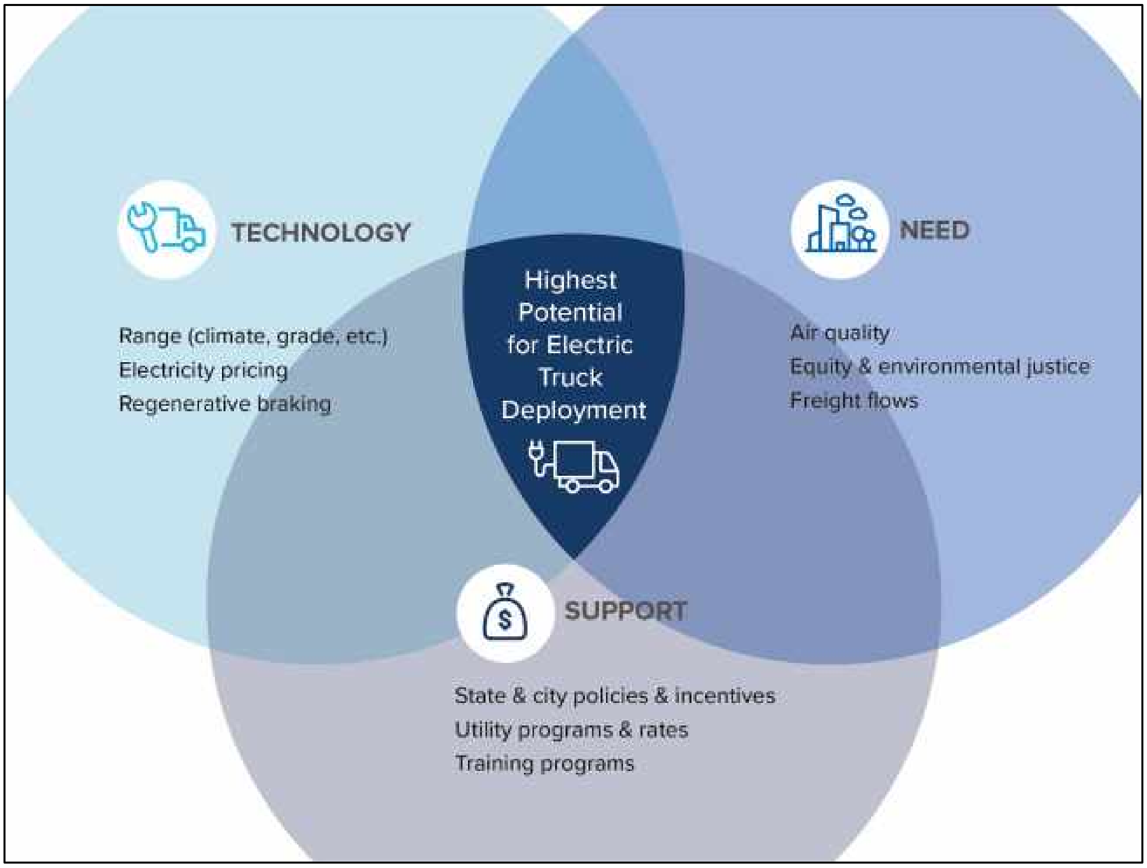
As part of this work, NACFE and RMI have embarked on a three-year project to gain a better understanding of how commercial battery electric vehicles fit into the regional haul market, which research has shown is an important segment of the trucking industry and also one that makes sense for electrification, given its short-haul nature and return-to-base operation (North American Council for Freight Efficiency 2020). Funded by Hewlett Foundation and ClimateWorks Foundation, this work includes:

- Identifying high-potential regional trucking routes
- Supporting implementation of first- and next-mover deployments
- Scaling of best practices in infrastructure deployment
- Increasing confidence in the value of electrification

NACFE and RMI released a new report in August 2020, *High-Potential Regions for Electric Truck Deployments*, that proposes a three-part framework that the industry can use to prioritize regions for electric truck deployments:

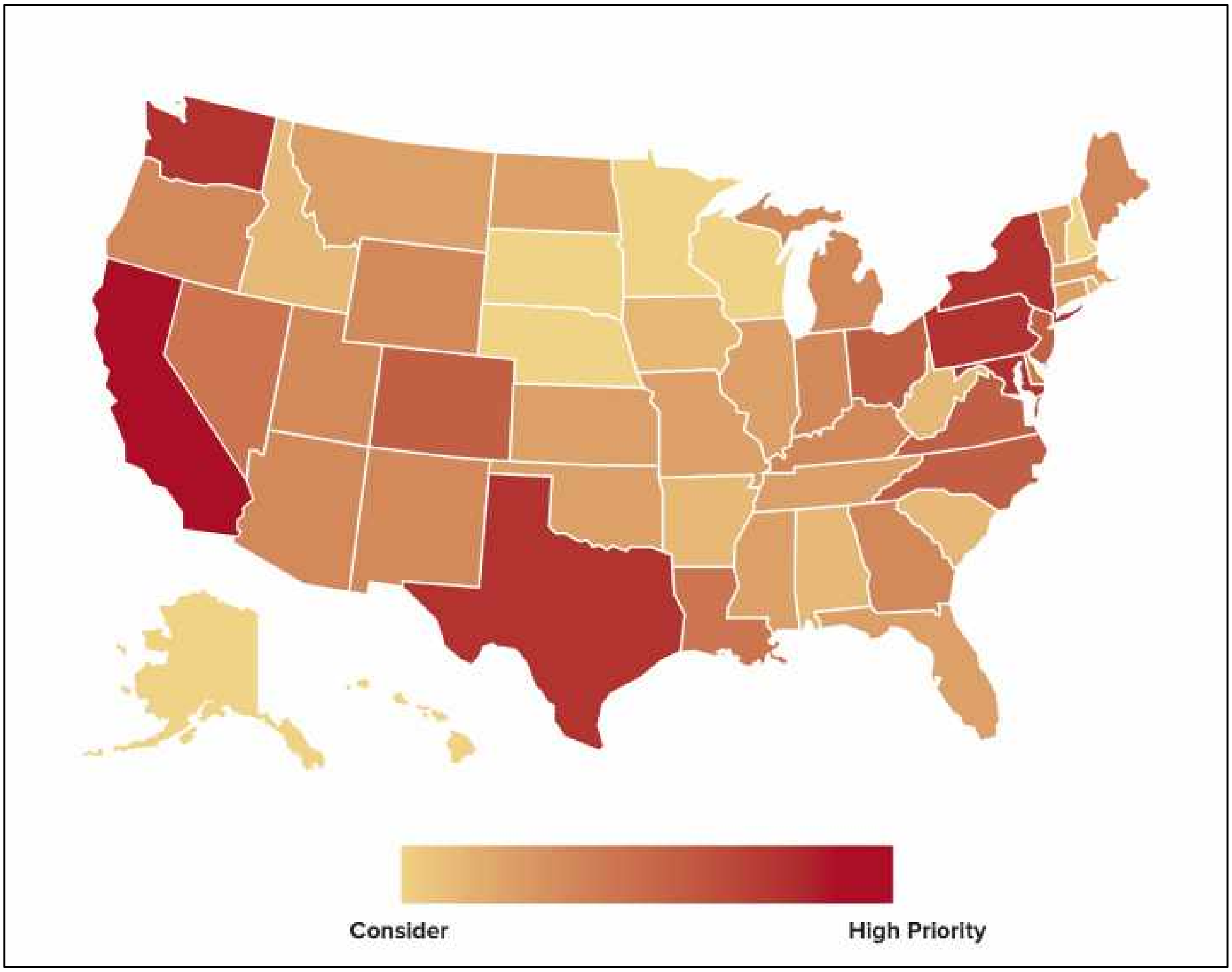
- **Technology** – Identify the regions that are most favorable to the unique attributes of the technology itself.
- **Need** – Identify the regions that exhibit the greatest need for the technology.
- **Support** – Identify the regions that provide the most support for the technology.

Figure 1: Framework for Identifying and Prioritizing High-Potential Regions for Electric Truck Deployments



The report also presents an initial analysis of where these three criteria come together to create a "hotspot" for near-term regional haul electric truck deployment. Regions are rated based on these criteria, resulting in a "heatmap" of electric truck potential by state, which distinguishes between regions fleets should *consider* to those that are the *highest priority* for electric truck deployments.

Figure 2: Heatmap of High-Potential Regions for Electric Truck Deployments



The aim of this analysis is to initiate a data-informed dialogue about which regions have the highest potential for successful regional haul electric truck deployments and why, and to spur feedback from the industry. This technical appendix provides detailed information on the methodology used in *High-Potential Regions for Electric Truck Deployments*.

Overview of Analytical Approach

The analytical approach of *High-Potential Regions for Electric Truck Deployments* consisted of three main steps: the study team (1) identified two to three indicators for each category in the framework; (2) evaluated data for each of the indicators at the state level; and (3) scored states based on their potential for successful electric truck deployments.

For this initial analysis, all indicators were weighted equally, and each had a maximum potential score of two points. There were eight indicators in total, for a total maximum potential score of sixteen.

States with the highest scores are indicated on the heatmap as "high priority," while states with lower scores are designated as regions the industry should "consider" for regional haul electric truck deployments.

We tried to use publicly available data whenever possible. Some considerations mentioned in the full report were not analyzed for this analysis, either because data was not available or because it varies significantly within states (e.g., grade).

The *High-Potential Regions for Electric Trucks Data Analysis Tool*, available for download, includes the data and calculations used in this initial analysis. Stakeholders are encouraged to use this tool to run their own analyses using data specific to the vehicles within their fleet or jurisdiction.

Figure 3: High-Potential Regions for Electric Trucks Data Analysis Tool

Category	Technology		Need			Support		
Indicator	Climate (Heating & Cooling Needs)	Benefit of Electricity Compared to Diesel*	Air Quality Nonattainment Levels	Lifecycle Emissions Benefits	Freight Flow	Supportive Policies & Incentives	Expressed Interest	Funding Availability
Metric	Sum of heating degree days (HDD) and cooling degree days (CDD)	using electricity rather than diesel	Population of Counties in Nonattainment for ozone	How Much Better than Diesel	Freight Transported	# of Policies	NESCAUM electric truck MOU signatory	Approved VW Funding & Utility Investment
State								
Alabama	4751	39%	0	60%	92197	0	No	$ 1.65
Alaska	8847	21%	0	80%	103113	0	No	$ -
Arizona	5793	59%	4,032,394	62%	41384	0	No	$ 4.20
Arkansas	5288	54%	0	68%	57810	0	No	$ 1.53
California	2267	38%	34,676,363	80%	349008	4	Yes	$ 50.83
Colorado	7285	51%	3,329,773	52%	85969	1	Yes	$ 1.27
Connecticut	6139	11%	3,574,097	78%	25673	0	Yes	$ -
Delaware	5808	57%	538,479	72%	5491	1	No	$ 2.30
District of Columbia*	5567	45%	601,723	72%	1374	0	No	$ 18.97
Florida	3953	54%	0	62%	117468	0	No	$ -
Georgia	4679	51%	3,669,376	60%	94699	0	No	$ -
Hawaii	4451	-33%	0	55%	6848	0	Yes	$ -
Idaho	6555	63%	0	77%	47339	0	No	$ 3.34
Illinois	7382	54%	8,615,813	44%	216505	0	No	$ 1.89
Indiana	6644	45%	605,972	56%	100440	0	No	$ 1.74
Iowa	7805	47%	-	57%	129311	0	No	$ 1.42
Kansas	6547	48%	-	51%	105197	3	No	$ 2.07
Kentucky	5888	48%	1,223,699	58%	103379	1	No	$ -
Louisiana	4196	55%	-	68%	233898	0	No	$ 3.41
Maine	7344	41%	-	78%	14464	0	Yes	$ 4.13
Maryland	5866	55%	5,067,669	72%	24078	0	Yes	$ 4.33
Massachusetts	6201	26%	-	78%	22586	0	Yes	$ 0.62
Michigan	7080	42%	5,055,023	54%	120699	0	No	$ 1.91

Indicator Analysis

As mentioned above, the study team evaluated multiple indicators for each of three overarching framework categories:

- Technology
- Need
- Support

How these indicators were evaluated is explained below and is summarized in the following table.

Figure 4: Summary of Analysis for High-Potential Regions for Electric Truck Deployments

Category	Indicator	Metric	Data Source	Data Year	Scoring
Technology	Climate	Sum of heating degree days and cooling degree days	Energy Star PortfolioManager Degree Days Calculator	2019	<5000 = 2 pts 5000-7000 = 1 pt >7000 = 0 pts
	Electricity Pricing	Percent savings from using electricity rather than diesel	EIA Electric Power Monthly, EIA Monthly Retail Diesel Prices, & study team analysis	2020	>40% = 2 pts 20-40% = 1 pt <20% = 0 pts
Need	Air Quality	Population of counties in nonattainment for ozone	EPA Green Book	2019	>1M = 2 pts 1-1M = 1 pt 0 = 0 pts
	Greenhouse Gas Emissions	Percent reduction in lifecycle GHG emissions compared to diesel	UCS Ready for Work report	2019	70+% = 2 pts 50-69% = 1 pt 35-49% = 0 pts
	Freight Flow	Ton-miles	BTS State Transportation Statistics	2018	>100B = 2 pts 50-100B = 1 pt <50B = 0 pts
Support	Supportive Policies & Incentives	Number of supportive policies in place	EV Hub Public Policies Map & CARB	2020	>2 = 2 pts 1 = 1 pt 0 = 0 pts
	Expressed Interest	NESCAUM zero-emission truck MOU signatory	Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding	2020	Yes = 2 pts No = 0 pts
	Funding Availability	Approved VW funding & utility investment per vehicle	EV Hub VW Settlement Dashboard, EV Hub Electric Utility Filings Dashboard & FHWA Highway Statistics	2020 & 2018	>$2 = 2 pts $0.01-$2 = 1 pt $0 = 0 pts

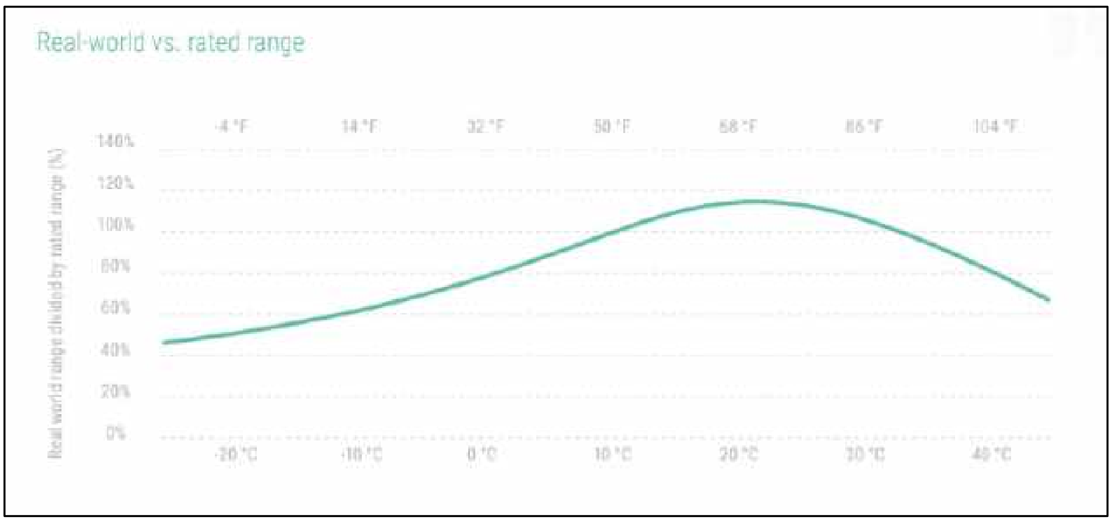
Technology

We assessed two indicators to determine which regions have the highest potential for electric trucks with respect to technology: climate and electricity pricing.

Climate

As mentioned in the report, climate is important because it impacts the battery performance and increases auxiliary loads for heating and cooling the cab and therefore reduces the range of the truck. Vehicles tend to maximize their range when operating in 70°F weather, with range decreasing as temperature increases or decreases (Fleetcarma 2020).

Figure 5: Impact of Temperature on Electric Vehicle Range

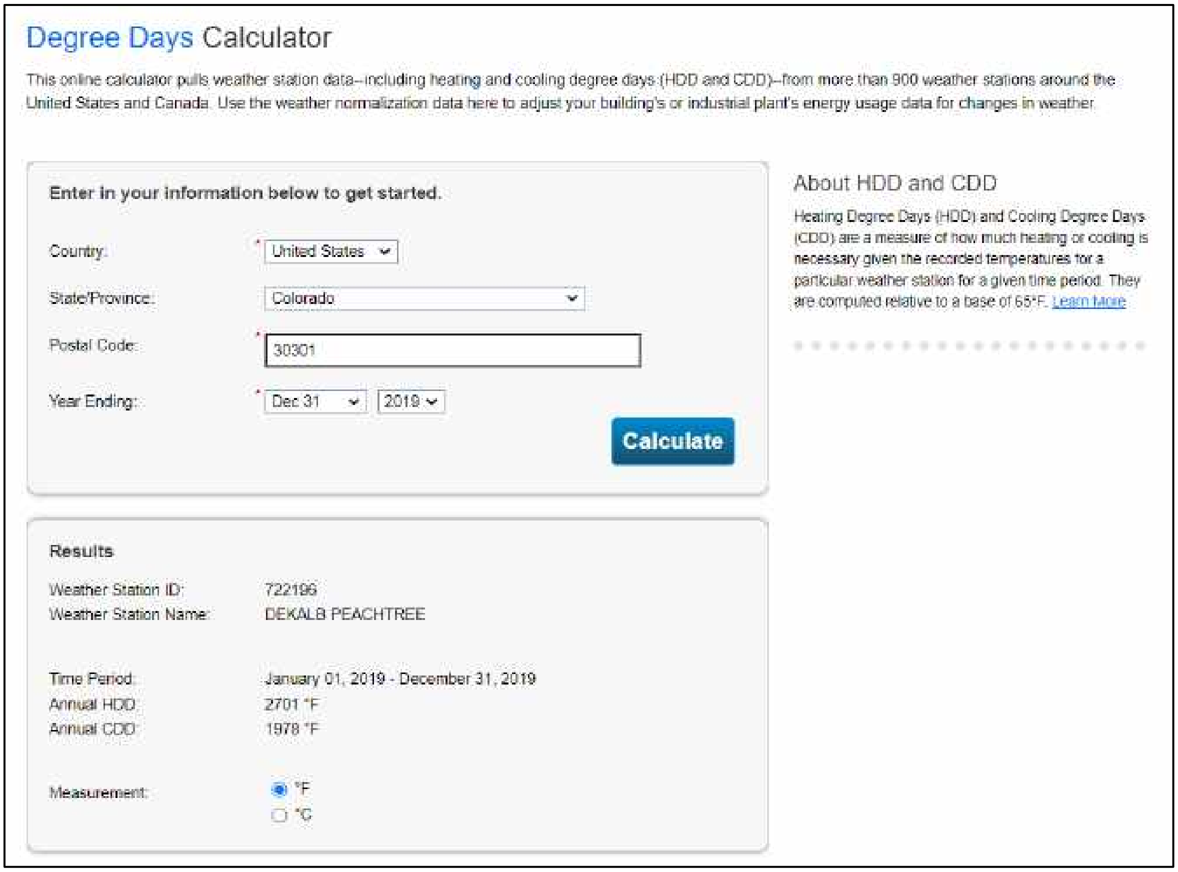


Source: Fleetcarma

In order to evaluate how ideal or not a climate is for electric trucks, we used data on heating degree days (HDD) and cooling degree days (CDD) by region. HDD and CDD are measures of how cold or hot, respectively, the temperature was on a given day or during a period of days in a particular location (US Energy Information Administration 2020). According to the US Energy Information Administration, a degree day "compares the mean (the average of the high and low) outdoor temperatures recorded for a location to a standard temperature, usually 65° Fahrenheit (F) in the United States. The more extreme the outside temperature, the higher the number of degree days." For example, a day with a mean temperature of 45°F has 20 HDD. Two such cold days in a row have a total of 40 HDD for the two-day period. Similarly, a day with a mean temperate of 85°F has 20 CDD.

HDD and CDD are used to estimate how much heating or cooling is necessary and are typically weighted according to the population of a region to estimate energy consumption. However, since this analysis is focused on vehicle energy use rather than home energy use, we utilized non-population-weighted data, available from Energy Star® PortfolioManager® (Energy Star PortfolioManager 2020). We analyzed the sum of CDD and HDD for 2019 for the biggest city in each state, assuming that the most freight is being moved near the largest cities. For example, Atlanta, Georgia had 2,701 HDD and 1,978 CDD in 2019, for a total of 4,679.

Figure 6: Degree Days Calculator



Source: Energy Star PortfolioManager

States with less than 5000 heating and cooling degree days scored 2 points for climate. States with 5001 to 7000 heating and cooling degree days scored 1 point, and states with more than 7000 heating and cooling degree days scored 0 points.

Electricity Pricing

The most obvious technological difference between electric and diesel trucks is the energy source – namely, electricity instead of diesel fuel. In order to evaluate which regions present the biggest opportunity for cost savings by switching from diesel to electricity, we couldn't simply analyze where electricity is cheapest, since this doesn't account for the regional variability in diesel prices or the increased efficiency of electric trucks. Instead, we compared the estimated cost of fueling a diesel truck with the estimated cost of charging an electric truck.

To conduct this analysis, we first calculated the electricity price per mile by multiplying each state's average price of electricity to commercial customers in April 2020 (US Energy Information Administration 2020) by an assumed average efficiency of 2.5 kWh/mile, based on existing vehicle specs compiled by CALSTART (CALSTART 2020). Then, to calculate the diesel price per mile, we multiplied the on-highway average retail price for diesel in January 2020 (US Energy Information Administration 2020) by an assumed national average efficiency of 0.17 gallons/mile (6.0 mpg), based on analysis from Run

On Less Regional (North American Council for Freight Efficiency 2020).[1] We used January rather than April 2020 diesel prices because we didn't want to skew the results by focusing on the temporary drop in price due to COVID-19. (Electricity prices are more highly regulated and therefore did not experience a drop in price due to COVID-19.) Finally, we compared these two costs.

States with potential savings of more than 40% from switching from diesel to electricity scored 2 points for electricity pricing. States with potential savings of more than 20% to 40% scored 1 point, and states with less than 20% potential savings scored 0 points.

Note that this analysis does not account for demand charges or other differences in electricity pricing that vary by utility. Though when considering deployments of electric trucks, fleets should be sure to understand the expenses they'll face for charging, including not only the electricity itself, but also the cost of the charger, software, and installation (if the fleet chooses to own the electric vehicle supply equipment [EVSE]) or the markup for these expenses and an administrative fee (if the fleet chooses to procure electricity via a charging-as-a-service model).

Need

We assessed three indicators to determine which regions have the highest potential for electric trucks with respect to need: air quality, greenhouse gas emissions, and freight flow.

Air Quality

Because they emit no tailpipe emissions, electric trucks offer an improvement in local air quality compared to diesel trucks, which emit air pollution that negatively impacts human health. Regions with particularly bad air pollution are designated as "nonattainment" with National Ambient Air Quality Standards.

To determine where electric truck deployments can provide the greatest good for the greatest number of people, we identified the total population living in 8-hour ozone (2015) nonattainment counties in each state in 2019 (US Environmental Protection Agency 2020).

States with more than 1 million people living in ozone nonattainment areas scored 2 points for air quality. States with some people but less than 1 million living in nonattainment areas scored 1 point, and states with no one living in nonattainment areas scored 0 points.

Greenhouse Gas Emissions

Although electric trucks have no *tailpipe* emissions – including greenhouse gas (GHG) emissions – they do still generate emissions upstream at the power plant used to generate the electricity. These emissions vary from region to region, depending on the generation mix of the local electricity grid. For example, some areas boasting a large supply from clean, renewable sources like wind and solar while others still rely more heavily on fossil fuels like coal and gas. Since many states, cities, and businesses

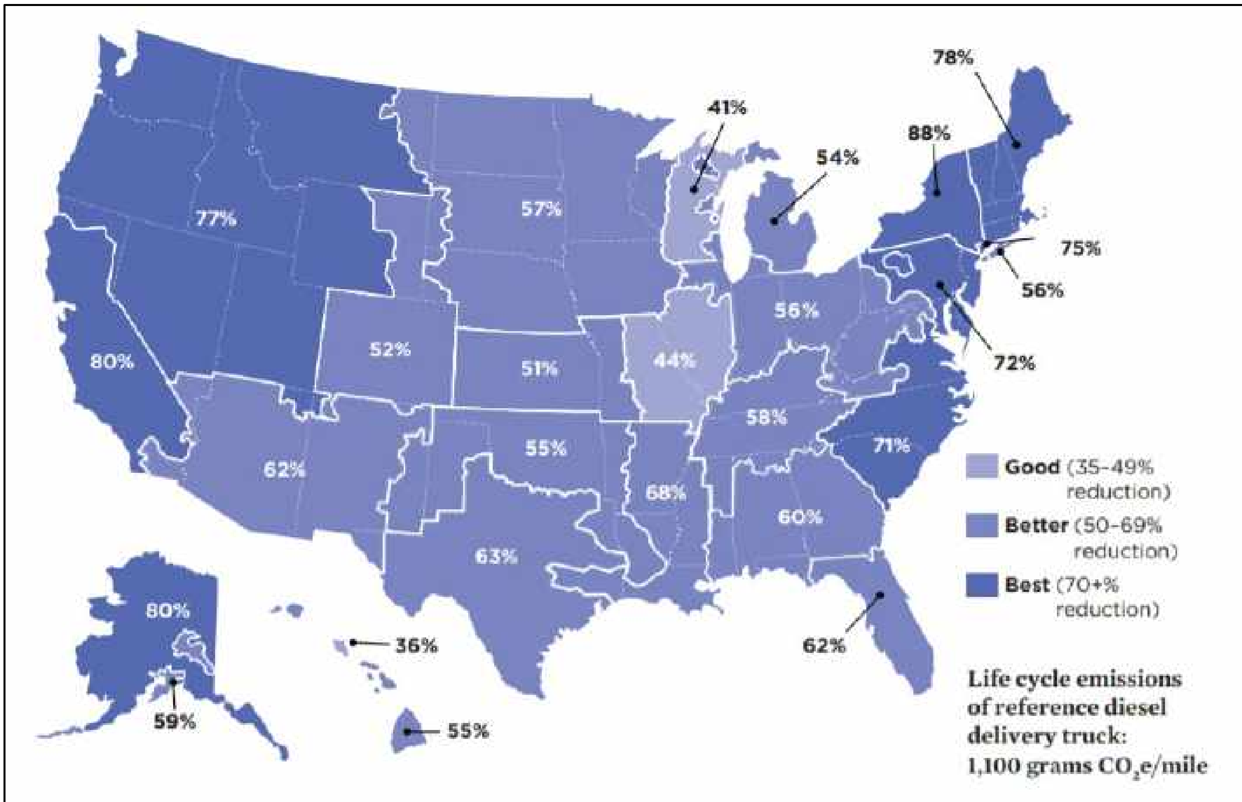
---

[1] Fleets in NACFE's annual fleet fuel study averaged 7.2 MPG for 2018 (North American Council for Freight Efficiency 2019), and in our Run on Less Regional, the nine diesel trucks averaged 8.7 MPG. The original Run on Less in 2017 saw long-haul trucks achieve over 10 MPG, reflecting what is feasible with well-trained drivers and modern trucks. This analysis uses the 6.0 national average, though we encourage stakeholders to use the framework provided here to run their own analysis using the average diesel efficiency of the vehicles within their fleet or jurisdiction.

are relying on electric vehicles to help achieve their ambitious climate and sustainability goals, near-term electric truck deployments should be prioritized where the grid is cleanest.

Union for Concerned Scientists (UCS) has published an analysis of lifecycle global warming emissions compared with diesel of trucks, and though they found that electric trucks already offer significant reductions in lifecycle global warming emissions in *all* regions of the United States, the benefits vary from region to region (Union of Concerned Scientists 2019).

Figure 7: Lifecycle Greenhouse Gas Emissions Benefits of Electric Trucks Compared to Diesel



This map shows life cycle global warming emissions as a function of different sources of electricity for a common type of delivery truck (Class 5 stepvan). Percentages represent emissions reductions for the electric delivery truck compared with a similar diesel delivery truck.

Source: Union for Concerned Scientists

For the purposes of our analysis, we utilized these percent reductions. If a state included multiple grid regions, we defaulted to the percentage reduction that applied to more of the geographic area of the state. For example, although parts of Texas are in grid regions where electric trucks are 62%, 55%, or 68% better than diesel trucks from a GHG perspective, the majority of the state is 63% better, so our analysis assumed 63% better for the entire state.

States considered "best" in UCS's analysis (representing a 70+% reduction in GHGs) scored 2 points for GHG emissions. States considered "better" (representing a 50-69% reduction in GHGs) scored 1 point, and states considered "good" (representing a less than 50% reduction) scored 0 points.

As the electric grid across the US gets cleaner and cleaner, so too will lifecycle emissions of electric trucks.

Freight Flow

Electric truck deployments are most needed in areas of high freight movement. Not only is freight activity a sort of proxy for the air pollution and GHG emissions challenges mentioned above, but it also highlights where freight movement is concentrated and therefore where fleets are most likely to influence their peers and help the industry as a whole move forward.

We evaluated fright movement based on data from the Bureau of Transportation Statistics about the number of ton-miles of freight being transported by state (Bureau of Transportation Statistics 2020).

States with more than 100 billion ton-miles scored 2 points for freight flow. States with more than 50 billion but less than 100 billion ton-miles scored 1 point, and states with less than 50 billion ton-miles scored 0 points.

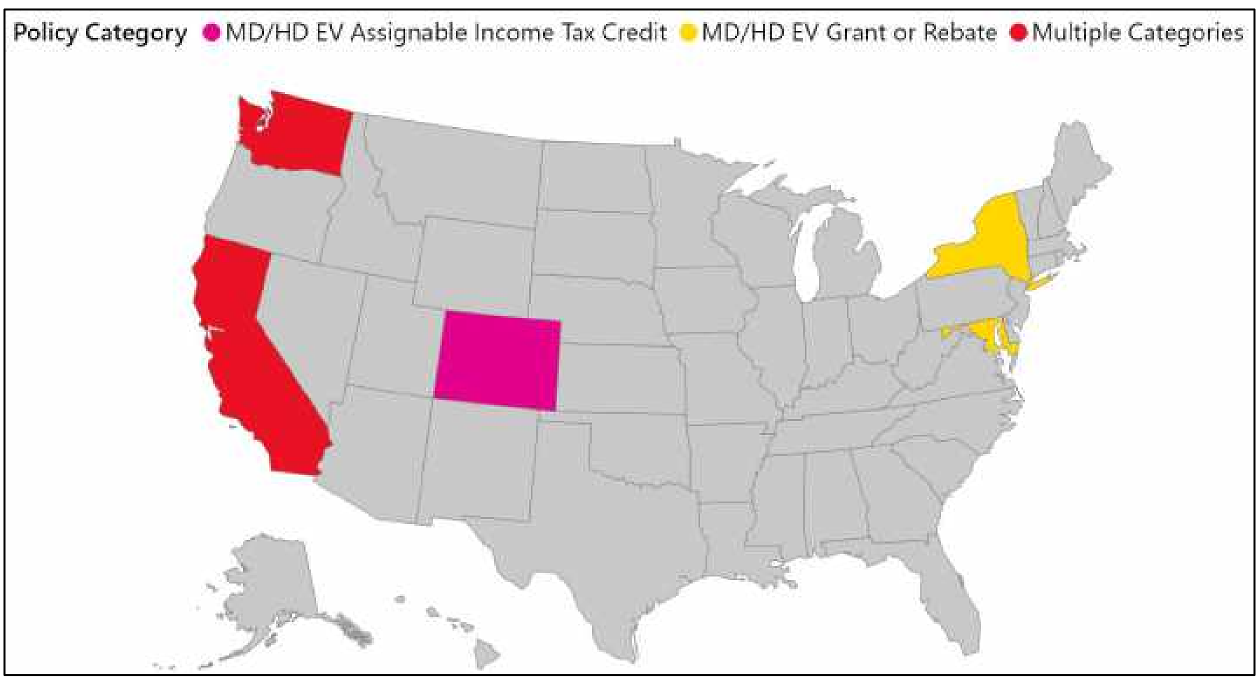
Support

We assessed three indicators to determine which regions have the highest potential for electric trucks with respect to support: supportive policies and incentives, expressed interest, and funding availability.

Supportive Policies and Incentives

Obviously, states with zero-emission truck mandates such as California's Advanced Clean Truck rule should be prioritized for electric truck deployments. However, some states also encourage electric trucks via incentives such as grants, rebates, income tax credits, sales tax exemptions, and loans. The more incentives available for electric trucks, the more likely a fleet is to be able to deploy them. Therefore, for this indicator, we look at the total number of these policies available, for which we relied on data from Atlas EV Hub (Atlas Public Policy 2020).

Figure 8: Medium- and Heavy-Duty Electric Truck Incentives Available



Source: Atlas EV Hub

Since California is the only state with a heavy-duty zero-emission vehicle mandate, they received an extra number added to their policy count.

States with two or more supportive policies or incentives scored 2 points for this indicator. States with one scored 1 point, and states with no supportive policies or incentives scored 0 points.

Expressed Interest

Some states may be interested in supporting deployments of zero-emission trucks though they have not yet been able to approve specific policies or incentives. These states should still be prioritized for deployments since stakeholders in these regions are likely to in the process of developing these sorts of policies and incentives and may themselves be incentivized by the interest expressed by policymakers to ensure the successful deployment of electric trucks.

As an indicator of expressed interest, we identified the fifteen states and District of Columbia that are signatories to the Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding, organized by Northeast States for Coordinated Air Use Management (NESCAUM) in June 2020.

Figure 9: Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding

MULTI-STATE MEDIUM- AND HEAVY-DUTY ZERO EMISSION VEHICLE

MEMORANDUM OF UNDERSTANDING

WHEREAS, the Signatory States and the District of Columbia[1] recognize the importance of state leadership and coordinated state action to ensure national progress in the effort to reduce greenhouse gas (GHG) emissions and stabilize global warming;

WHEREAS, the Signatory States have statutory obligations or otherwise seek to significantly reduce statewide GHG emissions by 2050, consistent with science-based targets;

WHEREAS, transportation is now the nation's largest source of GHG emissions, and, after light-duty vehicles, medium- and heavy-duty trucks are the next largest source of transportation sector GHG emissions;

WHEREAS, the Signatory States have a statutory obligation to provide their citizens with air quality that complies with national health-based air quality standards, which are required to be protective of health and the environment with an adequate margin of safety;

WHEREAS, fossil fuel related emissions from medium- and heavy-duty vehicles (MHDVs) are a major source of nitrogen oxides (NOx), particulate matter, and toxic air emissions, which are preventing many densely populated areas from achieving compliance with federal ambient air quality standards;

WHEREAS, emissions from MHDVs are a widely acknowledged, but unaddressed, environmental justice problem that directly and disproportionately impacts disadvantaged communities located near freight corridors, ports and distribution centers;

Source: NESCAUM

Signatory states scored 2 points for expressed interest, while non-signatories scored 0 points.

Funding Availability

Finally, we also considered funding availability for electric trucks from either VW settlement funds or approved utility filings. For data on both of these, again, we relied on Atlas EV Hub. We looked at the total amount of funding available for which zero-emission trucks are eligible and then determined the total amount of funding available per truck registered in the state, with data for the latter available from the FHWA (US Department of Transportation Federal Highway Administration 2019).

Figure 10: Approved Electric Utility Filings for Medium- and Heavy-Duty Electric Vehicles

Source: Atlas EV Hub

States with more than $2 available per vehicle scored 2 points for this indicator. States with some funding but less than $2 available per vehicle scored 1 point, and states with no funding available scored 0 points.

Table of Figures

Bibliography

Atlas Public Policy. 2020. *Atlas EV Hub.* https://www.atlasevhub.com.

Bureau of Transportation Statistics. 2020. *Freight Flows by State.* https://cms.bts.gov/freight-flows-state.

CALSTART. 2020. *Zero-Emission Technology Inventory.* https://globaldrivetozero.org/tools/zero-emission-technology-inventory/.

Energy Star PortfolioManager. 2020. *Degree days calculator.* https://portfoliomanager.energystar.gov/pm/degreeDaysCalculator.

Fleetcarma. 2020. *The Geography of EV Charging.* https://www.fleetcarma.com/resources/the-geography-of-ev-charging/.

North American Council for Freight Efficiency. 2019. "2019 Annual Fleet Fuel Study." December 29. https://nacfe.org/annual-fleet-fuel-studies/.

—. 2020. *Electric Trucks in Regional Haul Project.* https://nacfe.org/emerging-technology/electric-trucks-2/electric-trucks-in-regional-haul-project/.

—. 2020. *Run On Less Regional.* https://nacfe.org/run-on-less-regional-report/.

Union of Concerned Scientists. 2019. "Ready for Work: Now Is the Time for Heavy-Duty Electric Vehicles." December 11. https://www.ucsusa.org/resources/ready-work.

US Department of Transportation Federal Highway Administration. 2019. *Highway Statistics – 2018.* https://www.fhwa.dot.gov/policyinformation/statistics/2018/mv1.cfm.

US Energy Information Administration. 2020. *Degree days.* https://www.eia.gov/energyexplained/units-and-calculators/degree-days.php.

—. 2020. *Electric Power Monthly.* https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=table_5_06_a.

—. 2020. *Weekly Retail Gasoline and Diesel Prices.* https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_r10_m.htm.

US Environmental Protection Agency. 2020. *Current Nonattainment Counties for All Criteria Pollutants.* https://www3.epa.gov/airquality/greenbook/ancl.html.

About NACFE

The North American Council for Freight Efficiency (NACFE) works to drive the development and adoption of efficiency enhancing, environmentally beneficial, and cost-effective technologies, services, and operational practices in the movement of goods across North America. NACFE provides independent, unbiased research, including Confidence Reports on available technologies and Guidance Reports on emerging ones, which highlight the benefits and consequences of each, and deliver decision-making tools for fleets, manufacturers, and others. NACFE partners with Rocky Mountain Institute (RMI) on a variety of projects including the Run on Less fuel efficiency demonstration series, electric trucks, emissions reductions, and low-carbon supply chains. www.nacfe.org

About RMI

Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; Washington, D.C.; and Beijing. www.rmi.org