Understanding Zero-Emission Vehicle Realities

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ATRI

ATRI is not-for-profit research organization whose mission is to provide the data and analysis to improve the trucking industry's safety and productivity

ATRI's entire research portfolio is available at no cost on our website:

www.TruckingResearch.org

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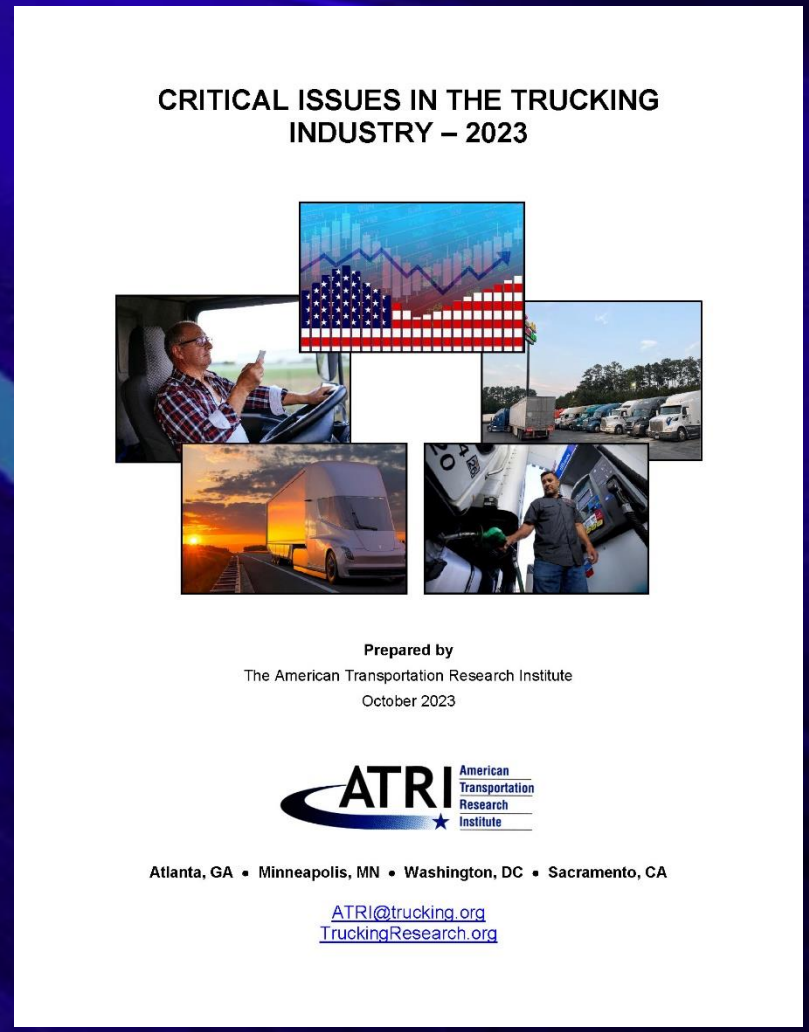
2023 Top Industry Issues

1. Economy (5)
2. Truck Parking (3)
3. Fuel Prices (1)
4. Driver Shortage (2)
5. Driver Compensation (4)
6. Lawsuit Abuse Reform (10)
7. Driver Distraction (#7 in 2018)
8. Driver Retention (7)
9. Detention / Delay at Customer Facilities (6)
10. Zero-Emission Vehicles



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2023 Top Industry Issues

Rank	Commercial Drivers	Motor Carriers
1	Driver Compensation	Economy
2	Truck Parking	Driver Shortage
3	Fuel Prices	Lawsuit Abuse Reform
4	Speed Limiters	Driver Retention
5	Detention / Delay at Customer Facilities	Fuel Prices
6	Driver Training Standards	Insurance Cost / Availability
7	Economy	Zero-Emission Vehicles
8	Broker Issues	Truck Parking
9	ELD Mandate	Diesel Technician Shortage
10	Autonomous Trucks	Driver Distraction

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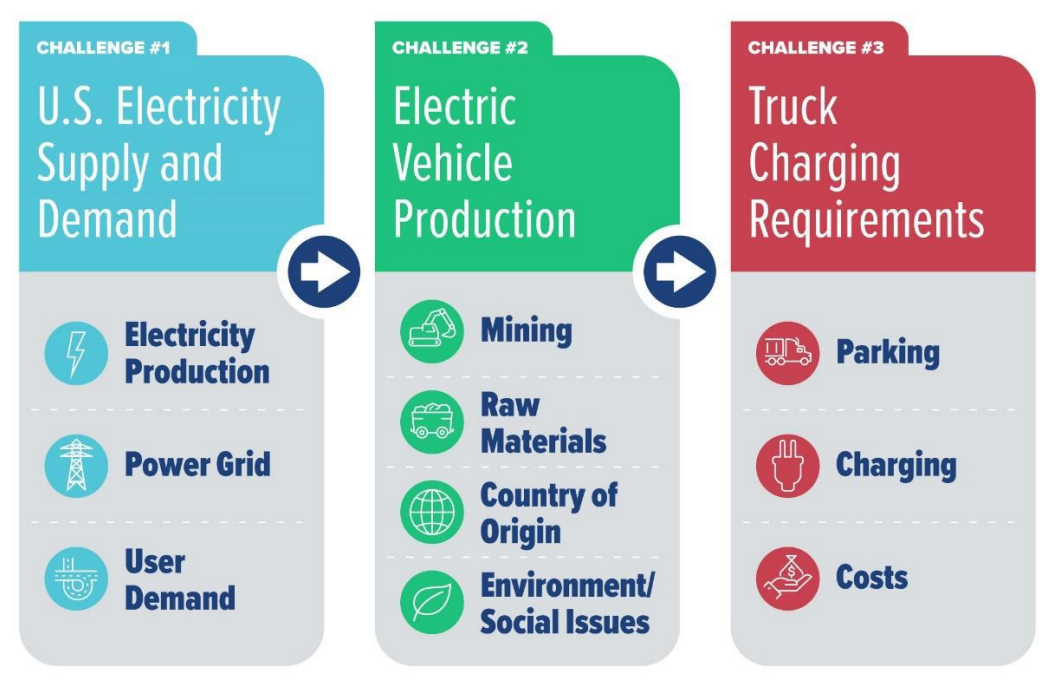
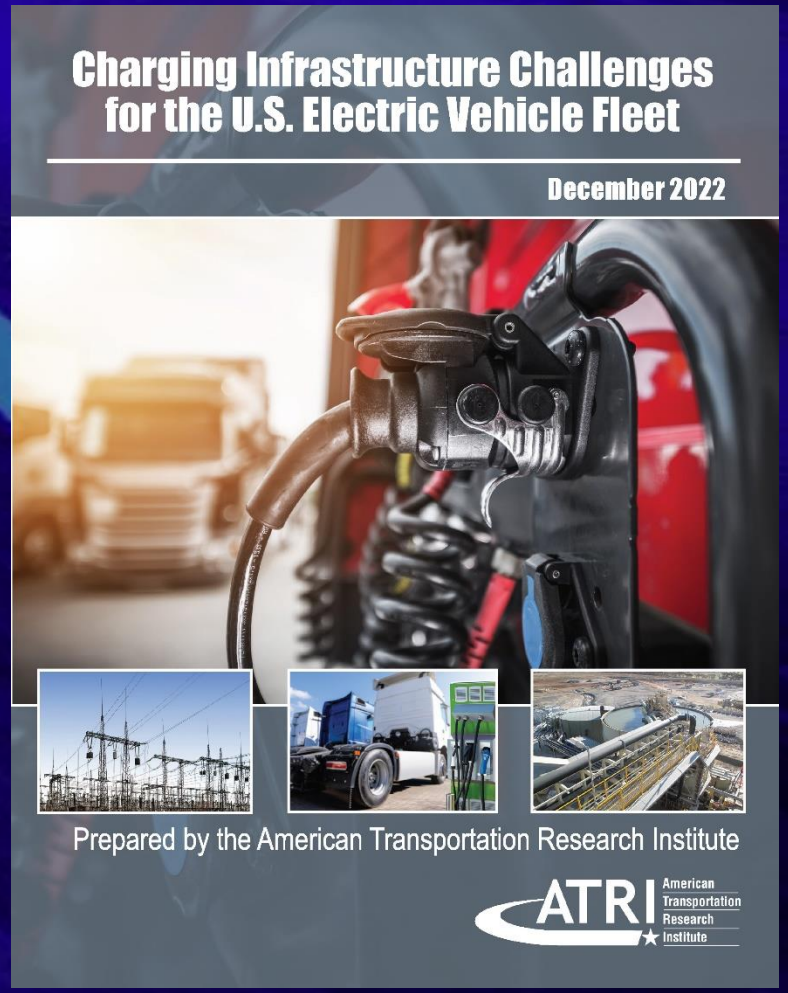
Charging Infrastructure Challenges for the U.S. Electric Vehicle Fleet

- **Analysis of three distinct challenges for EVs – with a focus on trucking**





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U.S. Electricity Supply and Demand

- **U.S. Vehicle Fleet**
  - **Autos: >253 million cars/light duty trucks**
    - **Electricity Needs: 1,039.9 billion kWh representing 26.3% of total U.S. consumption**
  - **Trucks: >12 million medium- and heavy-duty trucks**
    - **Electricity Needs: 553.5 billion kWh representing 14% of U.S. consumption**
    - **10.6% for 2.95 million combo trucks**
  - **Total: 1,593.8 billion kWh representing 40.3% of U.S. consumption**

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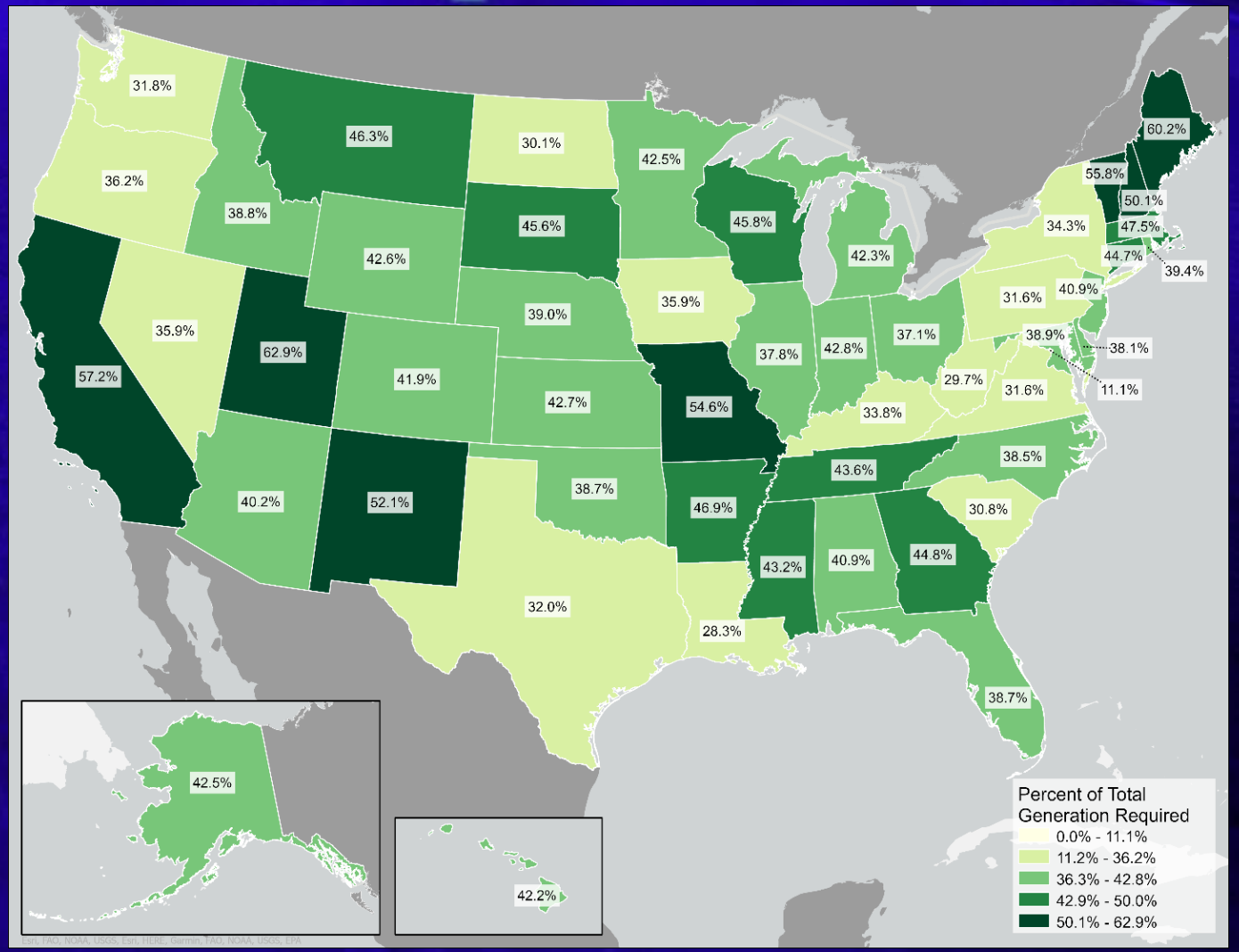
U.S. Electricity Supply and Demand



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Electric Vehicle Production

- **Electric battery materials are key issue**
  - **Mining: Cobalt, Graphite, Lithium, Nickel**
    - Project cost/lead time
    - Energy use and emissions (pollution and CO_2)
    - Geopolitical and social issues
  - **Refining of raw materials**
    - Heating, cooling, corrosive chemical reactions, mostly done in China
  - **Transportation sector requires staggering amount of these materials**

Electric Vehicle Production: Annual Mining

	Rank	Country	Production (Tons)	Percent of Total Production
Cobalt	1	Congo (Kinshasa)	132,277	70.6%
	2	Russia	8,378	4.5%
	3	Australia	6,173	3.3%
Graphite	1	China	903,894	82.0%
	2	Brazil	74,957	6.8%
	3	Mozambique	33,069	3.0%
Lithium	1	Australia	60,627	55.0%
	2	Chile	28,660	26.0%
	3	China	15,432	14.0%
Nickel	1	Indonesia	1,102,310	37.0%
	2	Philippines	407,855	13.7%
	3	Russia	275,578	9.3%

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The Nickel Pickle Quandary

EV Makers Confront the 'Nickel Pickle'

Large amounts of the mineral are needed for electric car batteries, but getting it out of the ground and refining it often requires clearing rainforests and generating large amounts of carbon

By Jon Emont Follow */ Photographs by Ulet Ifansasti for The Wall Street Journal*

June 4, 2023 9:25 am ET

In the electric-vehicle business, the quandary is known as the nickel pickle.

To make batteries for EVs, companies need to mine and refine large amounts of nickel. The process of getting the mineral out of the ground and turning it into battery-ready substances, though, is particularly environmentally unfriendly. Reaching the nickel means cutting down swaths of rainforest. Refining it is a carbon-intensive process that involves extreme heat and high pressure, producing waste slurry that's hard to dispose of.

The nickel issue reflects a larger contradiction within the EV industry: Though electric vehicles are designed to be less damaging to the environment in the long term than conventional cars, the process of building them carries substantial environmental harm.

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Tons of Material Needed versus Global Reserves

	Cobalt	Graphite	Lithium	Nickel
Global Reserves (Tons)	8,377,556	352,739,200	24,250,820	> 100,000,000
Total U.S. Vehicle Fleet Needs	5,396,733	29,586,708	3,842,239	18,807,908
Fleet Needs as a Percent of Known Reserves	64.4%	8.4%	15.8%	< 18.8%

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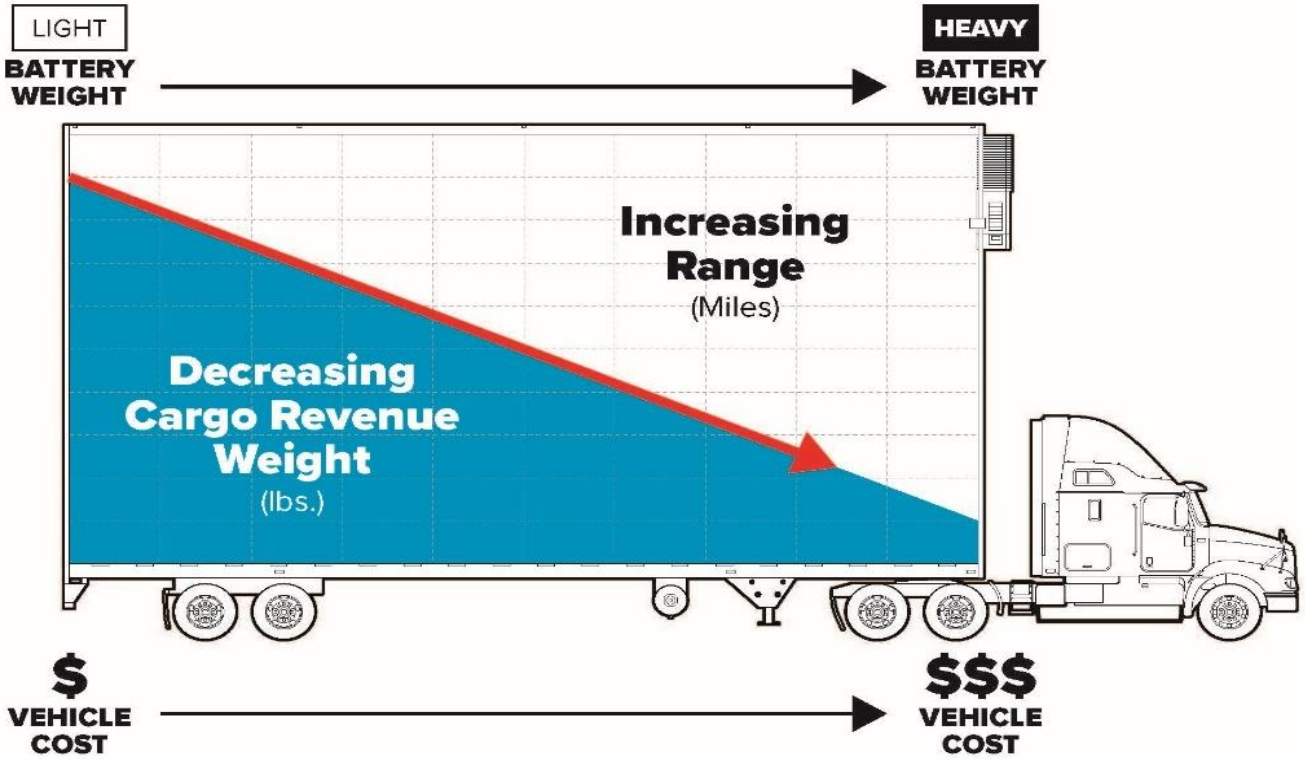
BEV Truck Conundrum



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Long-Haul Truck Charging Requirements

- **Final delivery point – truck parking locations**
  - **313,000 spaces – 1 for every 11 truck drivers**

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Long-Haul Truck Charging Requirements

- Initial equipment, installation costs
  - $35 billion
- Trucks will need more chargers than existing parking spaces
- Hours-of-Service limitations
- Interstate rest areas
  - No commercial activity/ charging at 40,000 spaces

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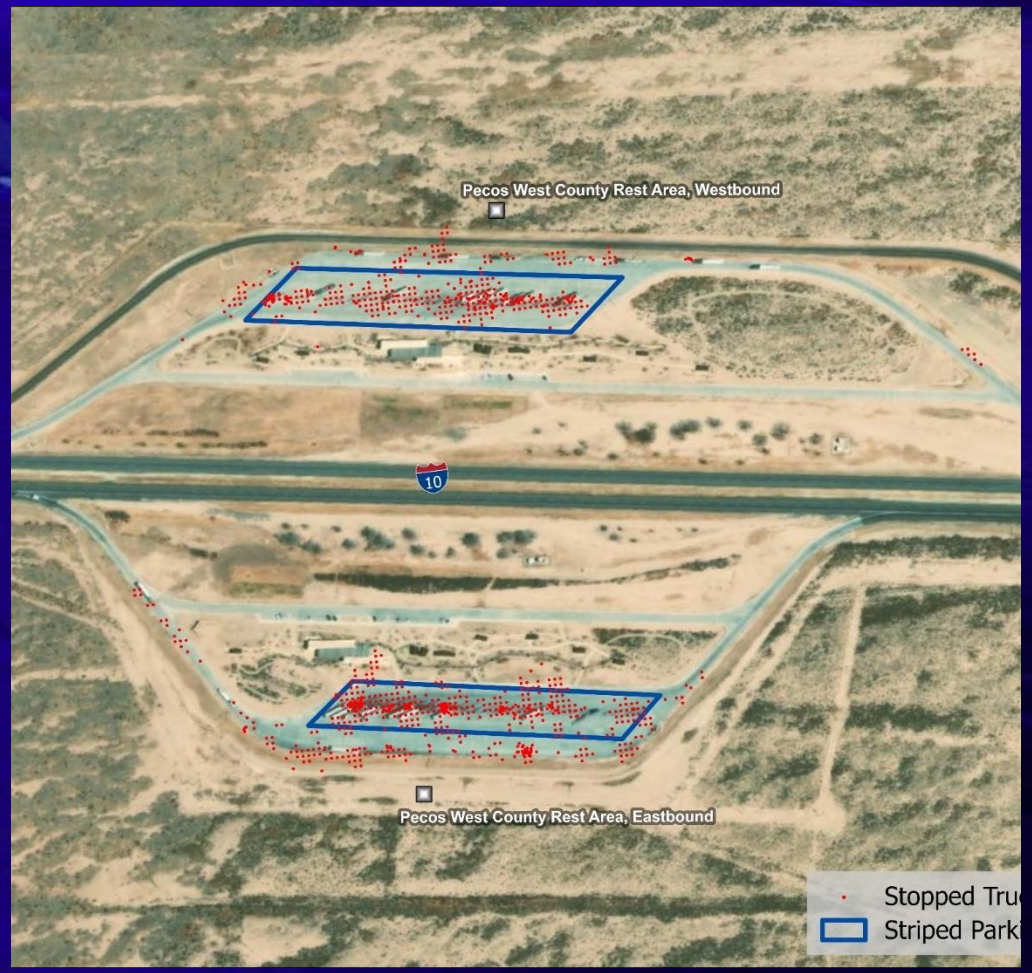
Parking Case Study

- Requires enough daily electricity to power more than 5,000 U.S. households for 126 truck charging events



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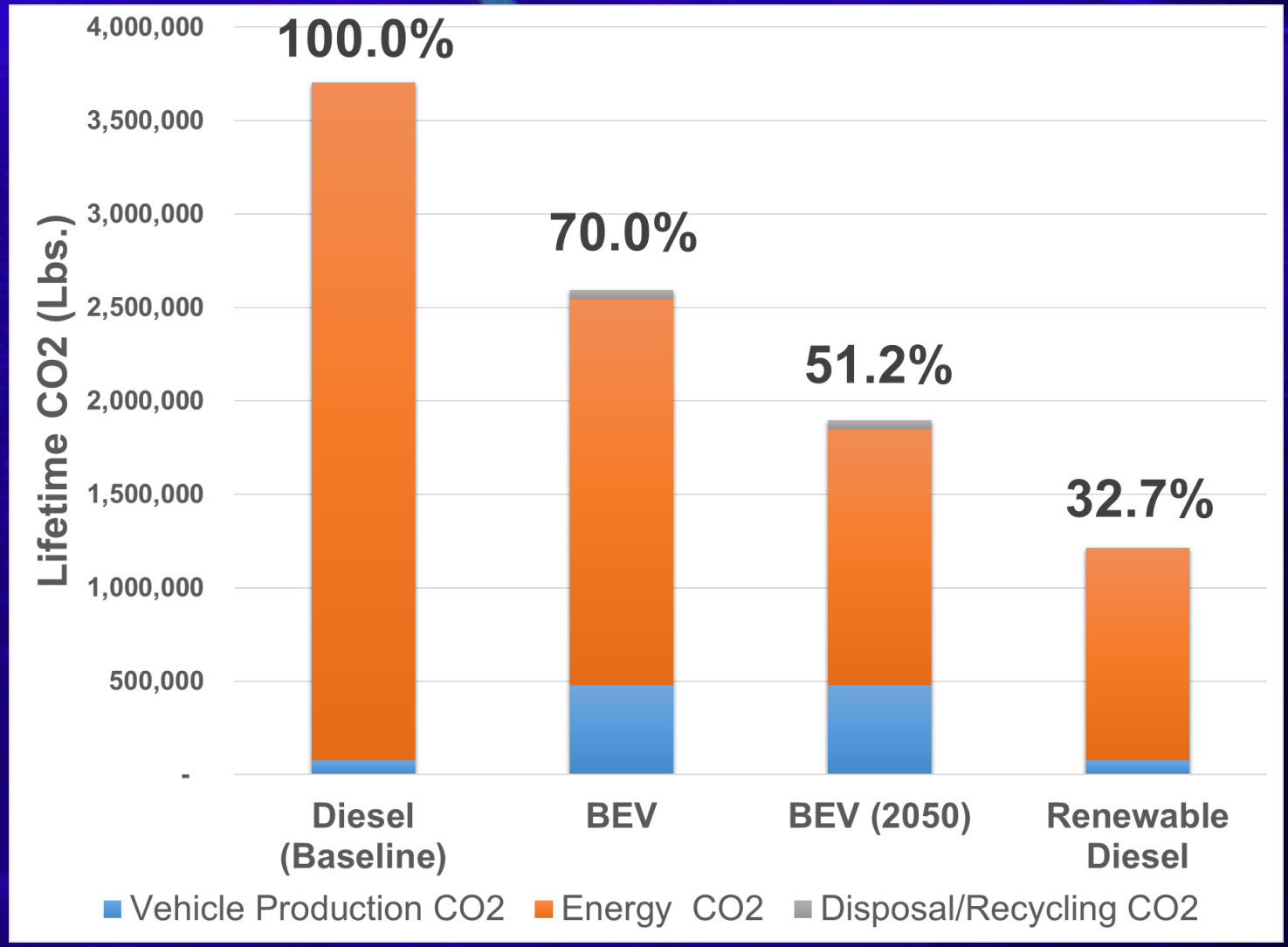
Goal: Decrease Emissions/CO_2



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ATRI Research on Zero-Emission Vehicles

NEW REPORT!

Understanding the CO_2 Impacts of Zero-Emission Trucks

New research from the American Transportation Research Institute (ATRI) analyzed the environmental impacts of Class 8 zero-emission trucks (ZETs). The research utilized federal and industry-sourced data to identify and compare full life-cycle CO_2 emissions for a range of truck types:

- Internal combustion engine (ICE) trucks powered by diesel
- Battery electric vehicle (BEV) trucks powered by electricity
- Fuel cell electric vehicle (FCEV) trucks powered by hydrogen

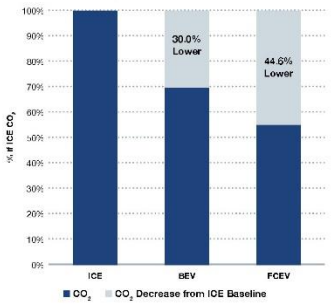
ATRI's analysis compared CO_2 emissions across the full vehicle life-cycle:

- Vehicle production
- Energy production and consumption
- Vehicle disposal/recycling

The study found that full life-cycle CO_2 emissions for the battery electric truck would only generate 30 percent fewer emissions than the standard diesel truck.

The marginal environmental benefits of electric trucks are due, in large part, to lithium-ion battery production – which generates more than six times the carbon of diesel truck production. ATRI's research concludes that hydrogen fuel cell trucks (FCEV) are ultimately the most environmentally friendly truck type, although the technology is not presently feasible for long-haul operations.

Lifetime CO_2 Emissions for Class 8 Diesel Truck (ICE) vs BEV & FCEV



Realities of Zero-Emission Trucks

VEHICLE COST
ZET vehicle costs will be a strong barrier to entry. While a new Class 8 diesel truck tractor may cost roughly $135,000 to $150,000, the purchase price of a new Class 8 BEV can be as much as $450,000. The same issue will likely impact the FCEV. Estimates for fuel cell truck costs range from $200,000 to $600,000 with 60 percent of the overall cost solely credited to the fuel cell propulsion system.

SOURCING OF MATERIALS AND SUPPLY CHAIN ISSUES
There are several key raw materials needed for lithium-ion batteries; depending on the battery chemistry, these might include lithium, graphite, cobalt, manganese and nickel. While these materials are critical for batteries and for the production of a large BEV national fleet, the U.S. is almost entirely dependent on other countries for these materials. Over the past decade, the U.S. has imported nearly 100 percent of the critical minerals needed for battery production from countries including China, Australia, Chile and the Democratic Republic of Congo.

REFUELING INFRASTRUCTURE
There currently is no U.S. network where over-the-road trucks can stop for rest breaks and recharging at the same time. In a forthcoming report, ATRI is documenting the infrastructure requirements of a nationwide truck charging network and the electricity sector's ability to power the U.S. truck fleet.

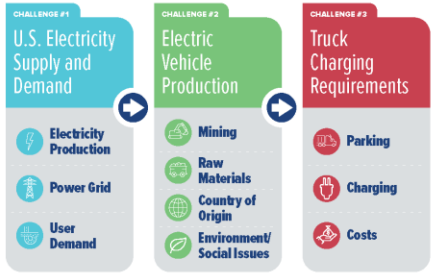
BATTERY LIFE
It is well understood that lithium-ion batteries begin to slowly degrade once the charging and discharging process commences, and battery degradation is greatly influenced by the number of charge cycles. Separate from the number of charging cycles, there is evidence that the *rate* at which a BEV is charged could impact battery life. Because of operational constraints – such as driver hours-of-service – and the large energy capacity of a truck battery, faster charging may be necessary.

NEW REPORT!

Charging Infrastructure Challenges for the U.S. Electric Vehicle Fleet

New research from the American Transportation Research Institute (ATRI) provides an assessment of the infrastructure needs for electrification of the U.S. vehicle fleet, with an emphasis on the trucking industry. This analysis focuses on three infrastructure components that may prove challenging for electrifying the nation's vehicle fleet:

1. U.S. Electricity Supply and Demand
2. Electric Vehicle Production
3. Truck Charging Requirements



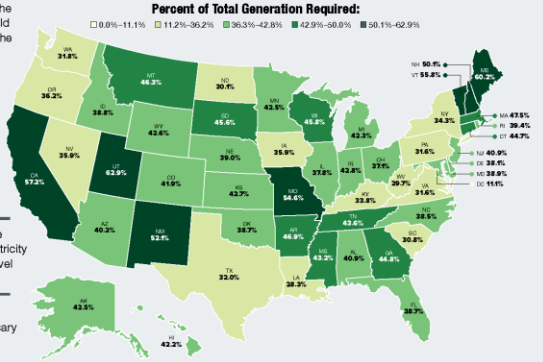
ATRI's research identified key findings in each of these three infrastructure components.

ELECTRICITY NEEDS ARE SIGNIFICANT
Full electrification of the U.S. vehicle fleet would require a large percentage of the country's existing electricity generation including:

- 26.3 percent for passenger cars and trucks
- 14 percent for all freight trucks, including 10.6 percent for long-haul trucks
- 40.3 percent for all vehicles

Some states would need more than 50 percent of current electricity generation to meet vehicle travel needs (see map at right).

Large-scale infrastructure investment would be a necessary precursor to electrification.



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Questions?

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