Analysis of Long-Haul Class 8 Battery Electric Trucks

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American Transportation Research Institute

ATRI

Trucking industry's not-for-profit research organization

- Safety
- Mobility
- Economic Analysis
- Technology
- Environment

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Today's Electric Truck Environment

- Vehicle costs – new Class 8 BEV truck could cost over $400,000
- No adequate refueling infrastructure
- Material sourced from outside U.S.
  - Lithium, graphite, cobalt, manganese and nickel
- CO_2 emissions are still substantial
- Public sector push to adopt ZEV

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Analysis of Class 8 Battery Electric Trucks

- Understanding the CO_2 Impacts of Zero-Emission Trucks
- Infrastructure Considerations for Electric Trucks

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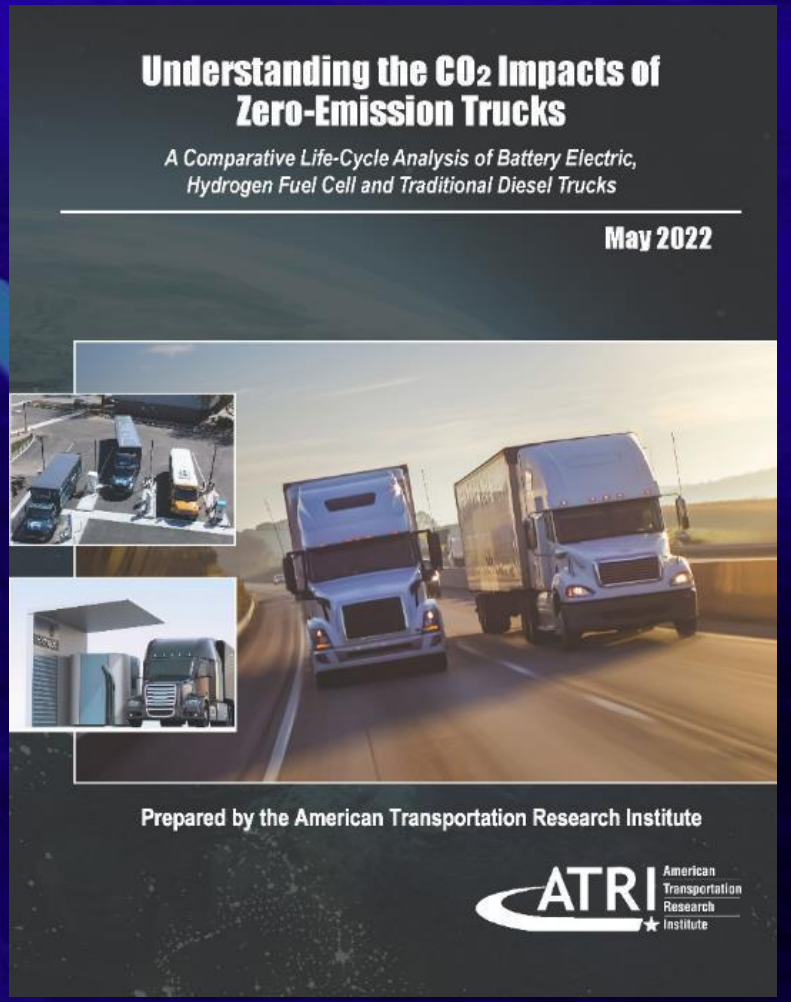
Understanding the CO_2 Impacts of Zero-Emission Trucks

- 2021 RAC Priority
- Life-cycle CO_2 emissions study for:
  - 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
- Compares CO_2 emissions across from the full vehicle life-cycle:
  - Vehicle production
  - Energy production and consumption
  - Vehicle disposal/recycling



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Research Approach

- Federal data – utilized GREET Model from USDOE Argonne National Lab
- Industry data sources
- Key vehicle assumptions
  - Class 8 sleeper cab
  - Vehicle life: 1,000,000 miles
  - Vehicle minimum range: 500 miles

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Vehicle Production Co_2 Emissions (lbs.)

	ICE	BEV	FCEV
Vehicle Components	56,103	49,916	97,348
Assembly	8,563	7,531	10,922
Battery	374	416,891	3,527
Fluid	9,687	3,717	3,717
Total	74,728	478,055	115,514

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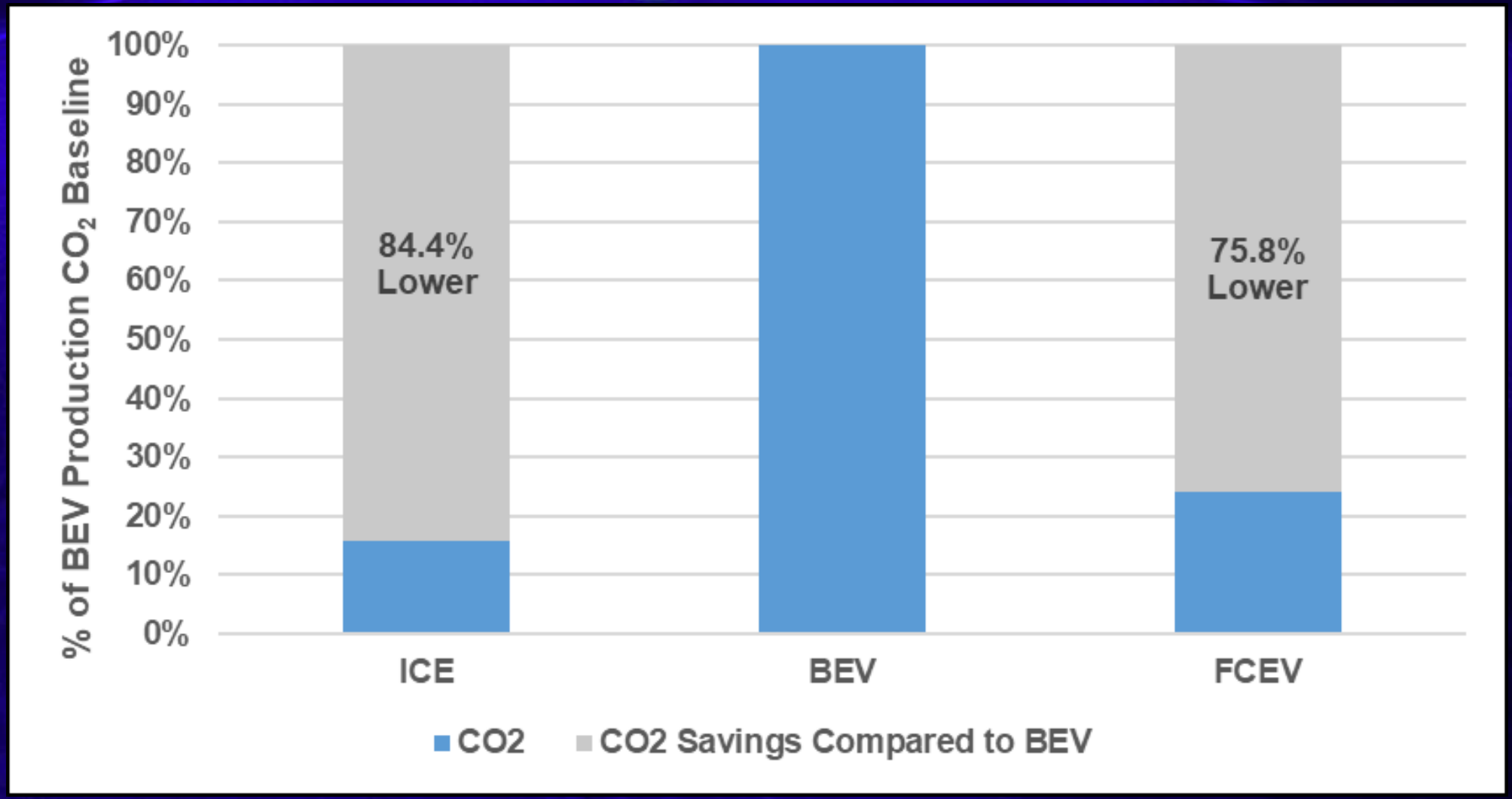
Vehicle Production



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Energy Production and Consumption

	ICE (diesel)	BEV (electricity)	FCEV (hydrogen)
Lifetime Average Fuel Economy	7.19 mpg	0.438 miles per kWh	10.61 miles per kg
Lifetime Fuel Consumption (1 million miles)	139,082 gallons	2,280,897 kWh	94,251 kg

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Energy Production and Consumption

	Fuel Production: Lbs. of CO_2 per Energy Unit	Fuel Consumption: Lbs. of CO_2 per Energy Unit	Total Lbs. of CO_2 per Energy Unit
Diesel (per gallon)	3.68	22.39	26.08
Electricity (per kWh)	0.91	-	0.91
Hydrogen (per kg)	20.50	-	20.50

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Energy Production and Consumption

CO_2 Emissions from Energy to Drive 1M Miles	ICE	BEV	FCEV
Energy Production (Lifetime Lbs. of CO_2)	511,655	2,065,341	1,932,422
Energy Consumption (Lifetime Lbs. of CO_2)	3,115,244	-	-
Total	3,626,899	2,065,341	1,932,422

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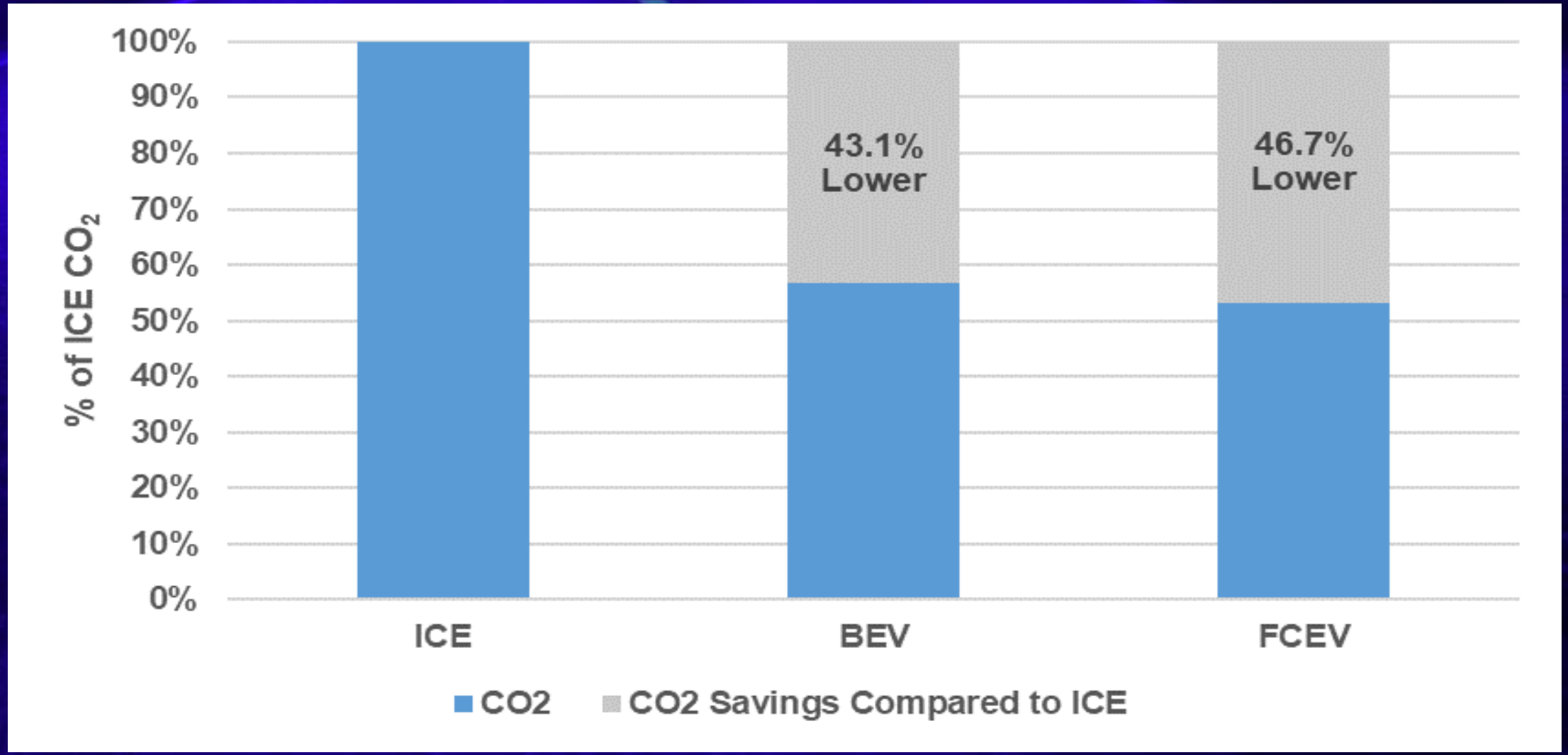
Energy Production and Consumption



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Disposal/Recycling

Total Lbs. of CO_2 for Vehicle End-of-Life Disposal/Recycling	ICE	BEV	FCEV
Disposal	2,268	2,268	2,268
Li-Ion Battery Recycling	-	48,255	575
Total	2,268	50,523	2,843

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Total Life-Cycle

	ICE	BEV	FCEV
Vehicle Production CO_2	74,728	478,055	115,514
Energy Production and Consumption CO_2	3,626,899	2,065,341	1,932,422
Disposal/Recycling CO_2	2,268	50,523	2,843
Total Life-Cycle CO_2	3,703,895	2,593,919	2,050,779

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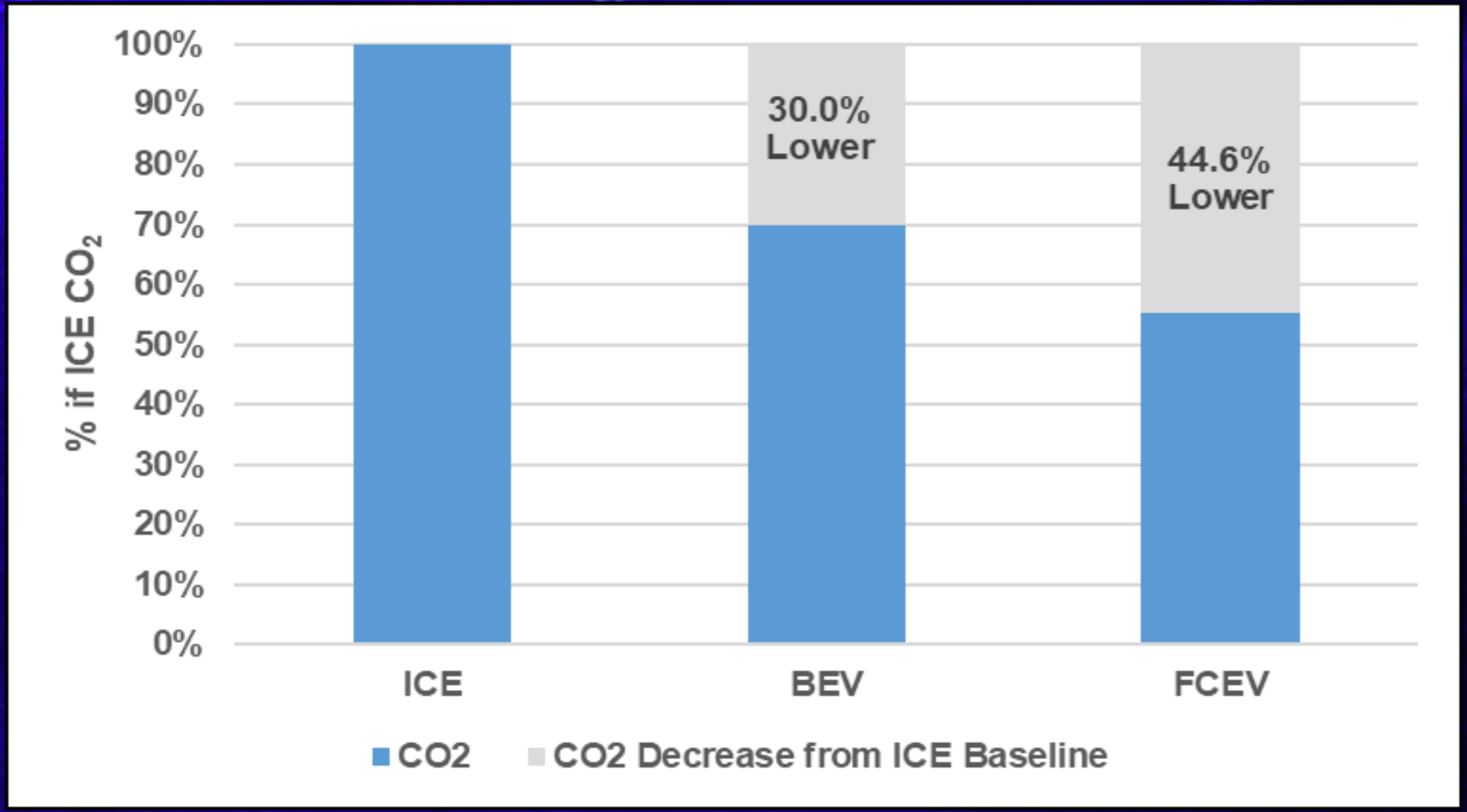
ICE Life-Cycle CO_2 vs BEV & FCEV



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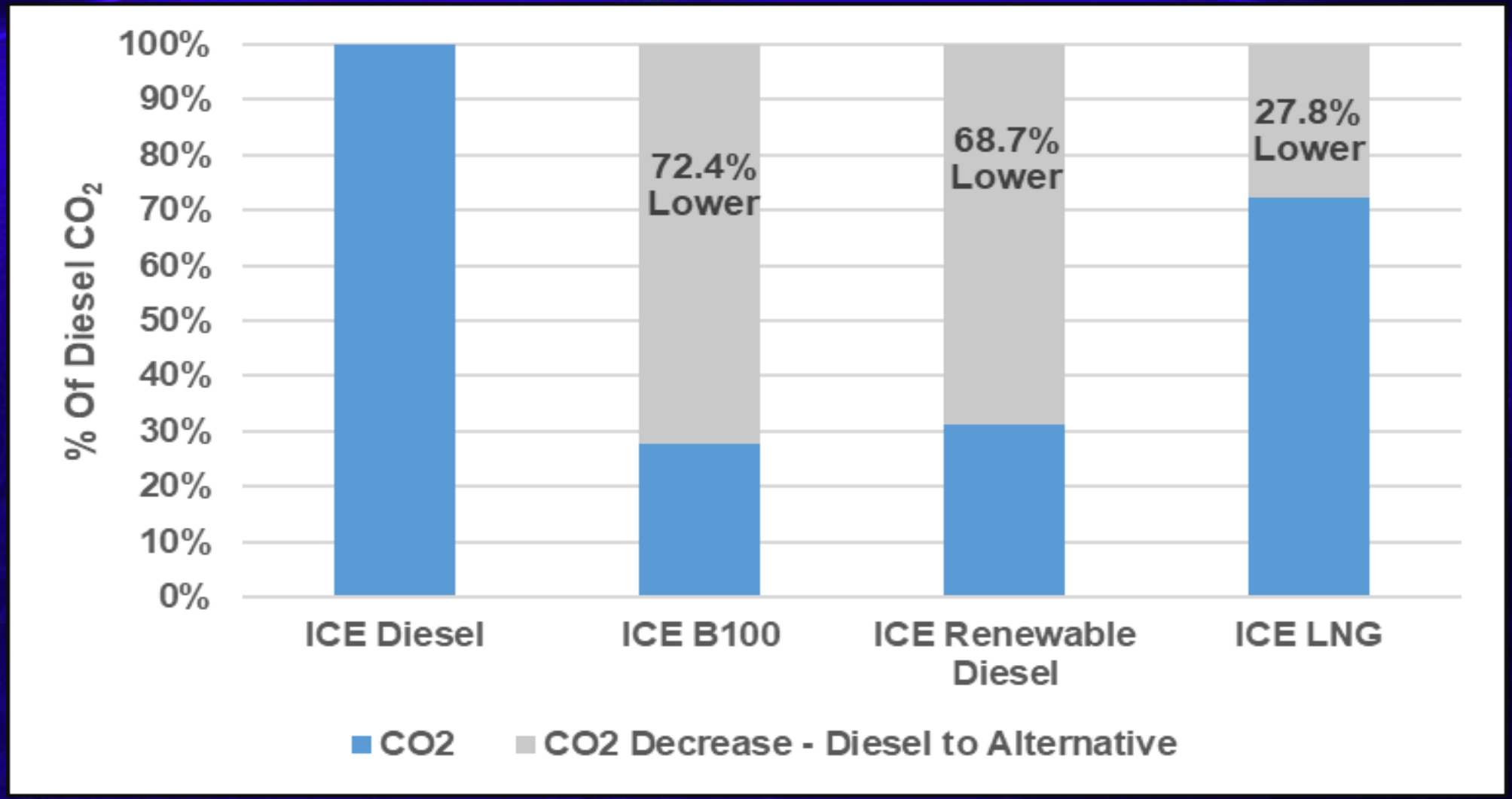
Diesel Alternatives



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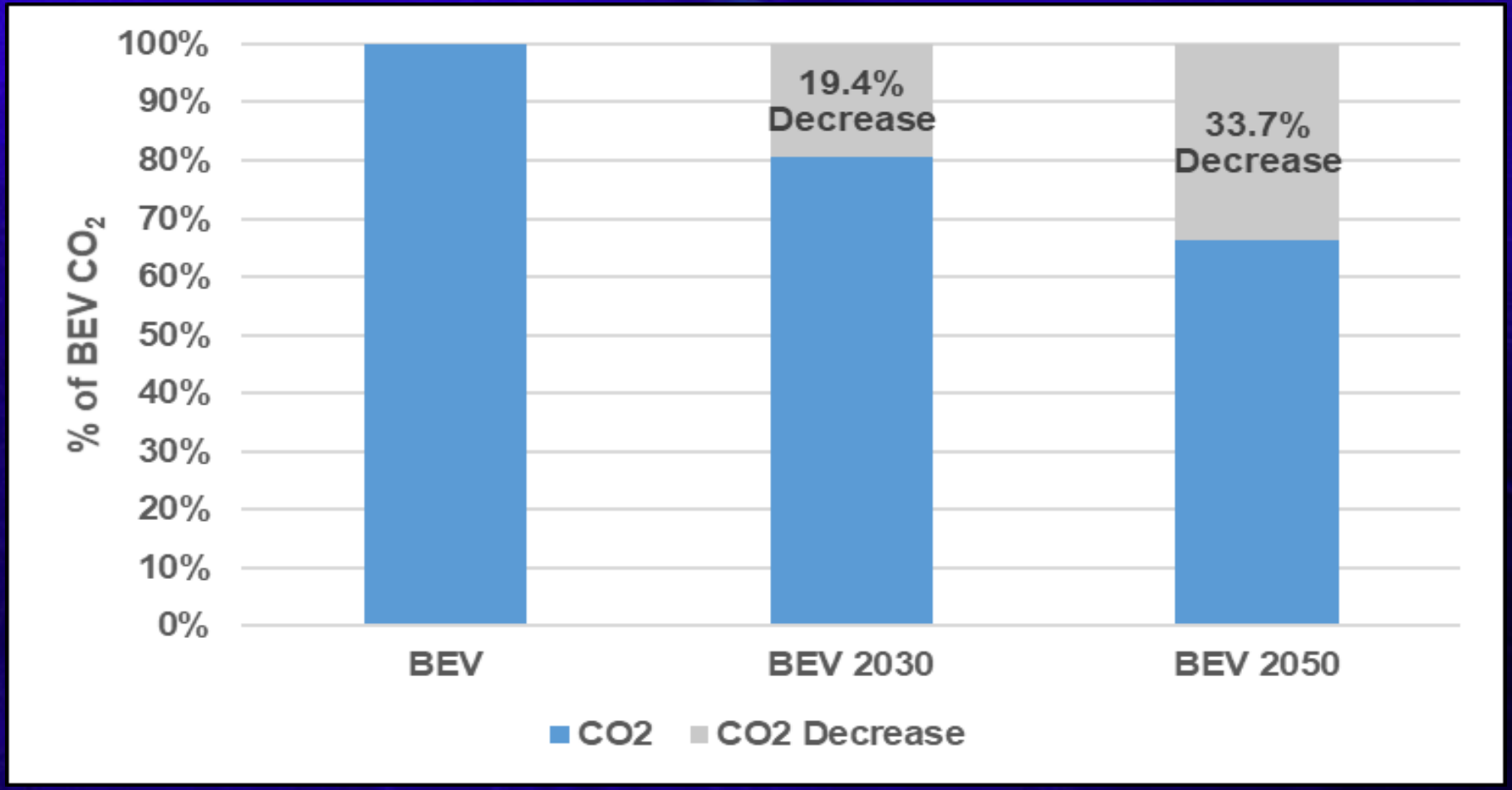
Projected Decrease in Fuel Production CO_2 for BEV



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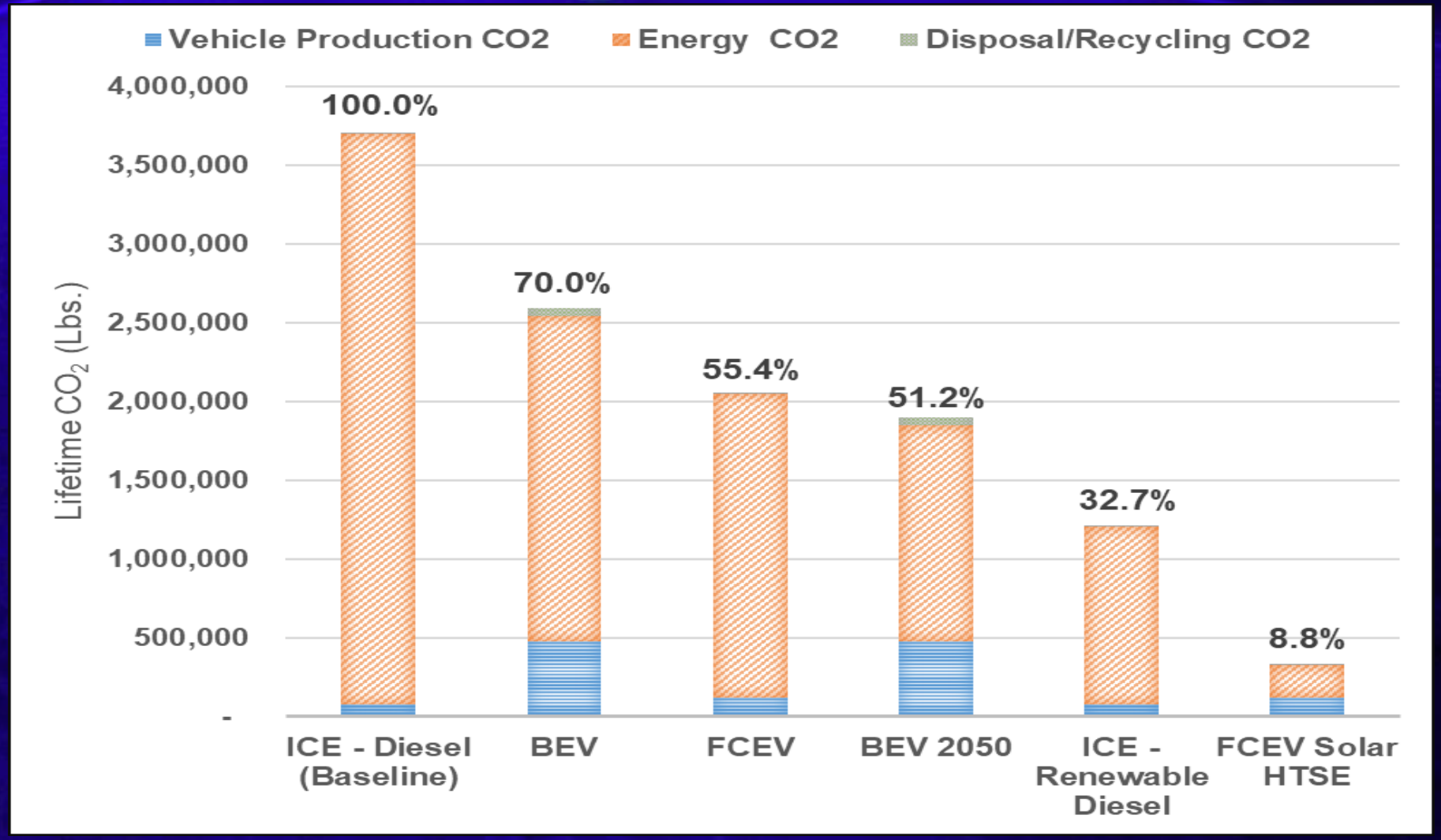
Key Findings



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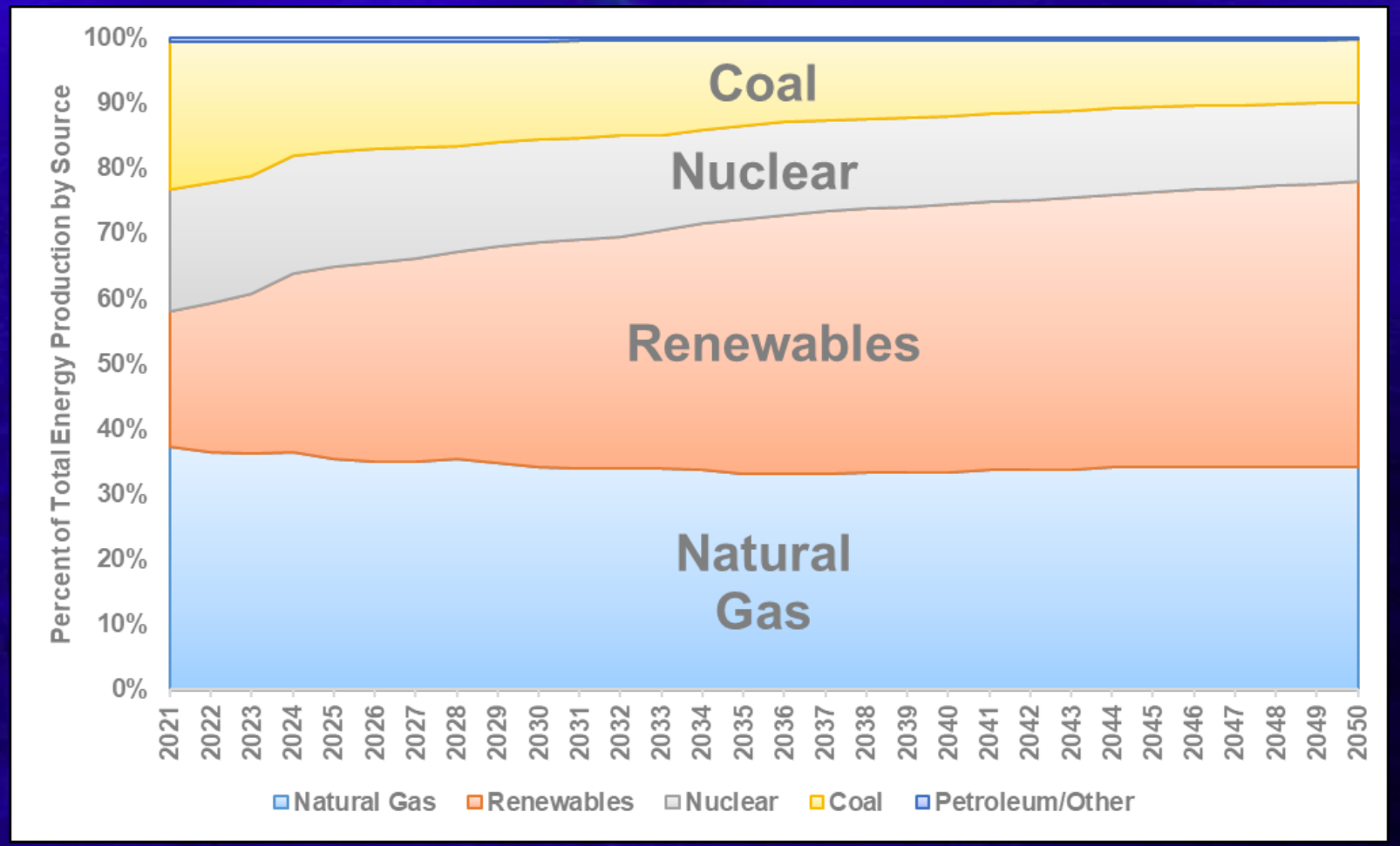
Infrastructure for Class 8 BEV

- **Energy Production and Distribution Considerations**
  - **Power Sources**
  - **Electricity Transmission/Distribution (the grid)**
  - **Supply/Demand**

EIA Electricity Source Projections



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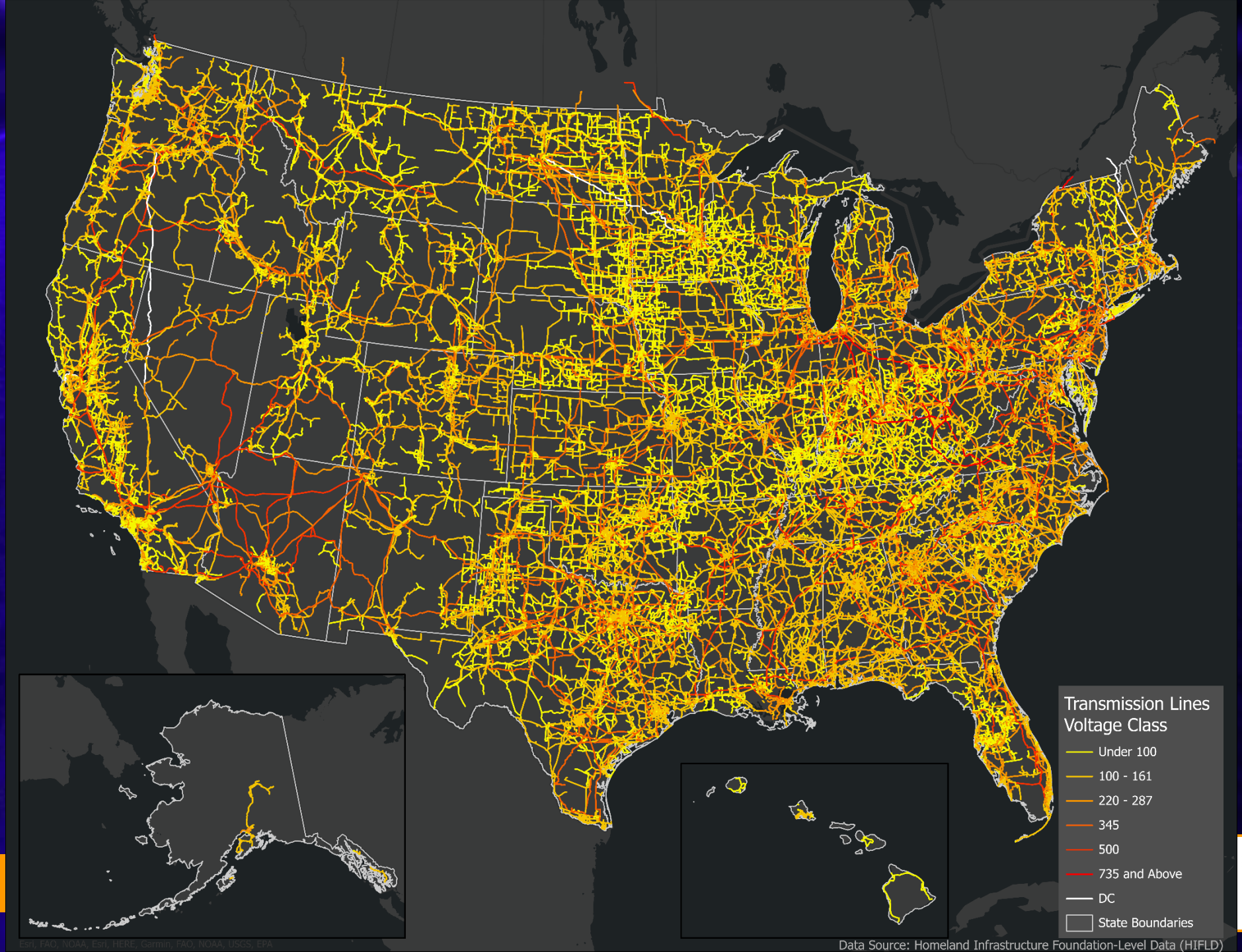

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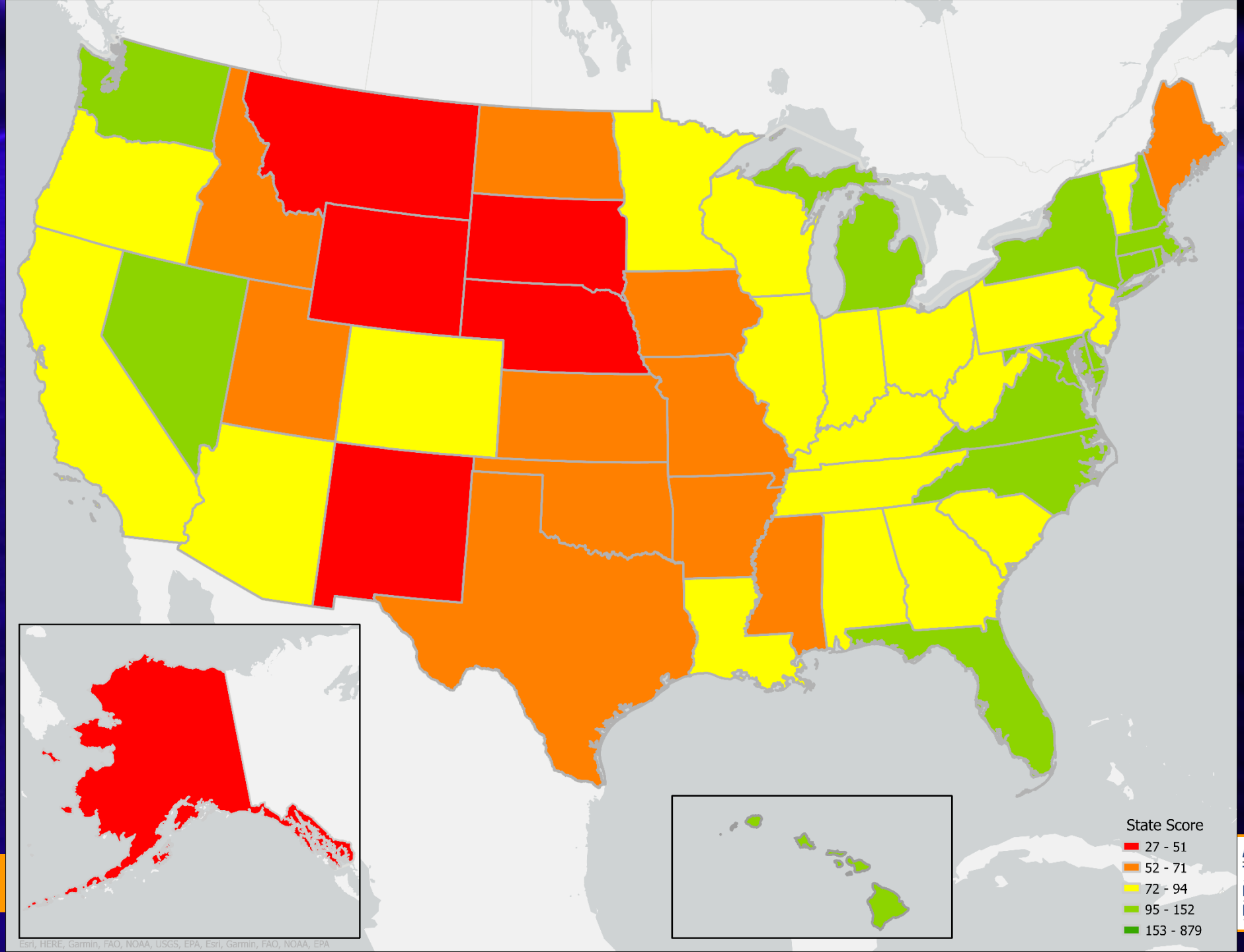
State Score
27 - 51
52 - 71
72 - 94
95 - 152
153 - 879
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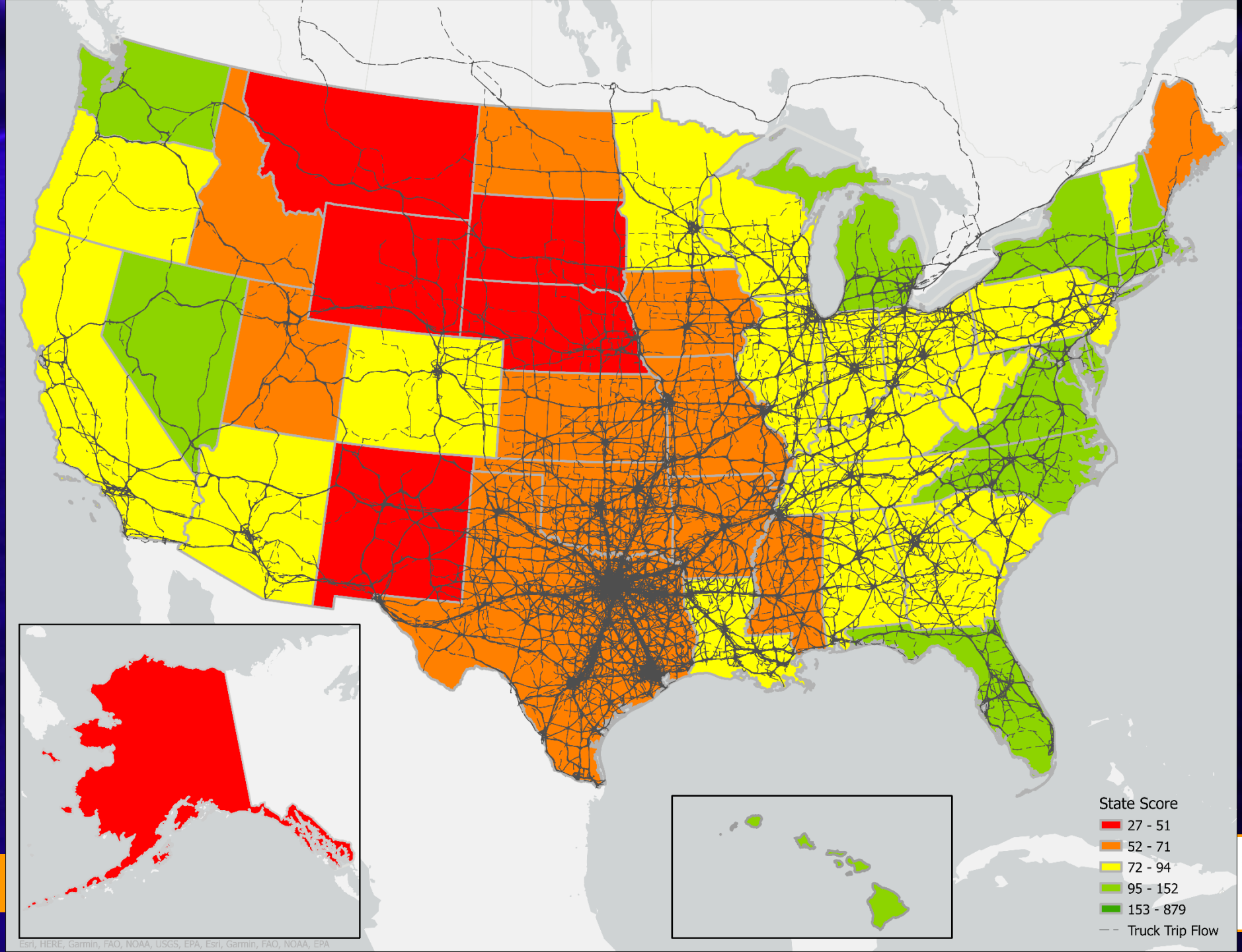
Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Esri, Garmin, FAO, NOAA, EPA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Truck Trip Flow
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Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Esri, Garmin, FAO, NOAA, EPA

Infrastructure for Class 8 BEV

- **Vehicle Considerations**
  - **Components**
  - **Weight and Cargo**
  - **Charging Locations and the Impact on Operations**

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Source Countries for Key Materials

Mineral	Key Source Countries	Global Production (metric tons)	U.S. Production (% of global)
Lithium	Australia (55%), Chile (26%), China (14%), Argentina (6.2%)	100,000	<5.00%
Graphite	China (82%), Brazil (6.8%), Mozambique (3%), Russia (2.7%)	1,000,000	0.00%
Cobalt	Democratic Republic of Congo (70.5%), Russia (4.4%), Australia (3.2%)	170,000	0.40%
Manganese	South Africa (37%), Gabon (18%), Australia (16.5%), China (6.5%)	20,000	0.00%
Nickel	Indonesia (37%), Philippines (13.7%), Russia (9.2%)	2,700,000	0.60%

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Lost Revenue Weight Analysis

Weight (lbs.)	ICE	BEV
Maximum Gross Weight	80,000	80,000
Tractor Weight	18,216	32,016
Trailer Weight	11,264	11,264
Vehicle Tare Weight	29,480	43,280
Available Revenue Weight	50,520	36,720
Lost Revenue Weight from Baseline		-13,800

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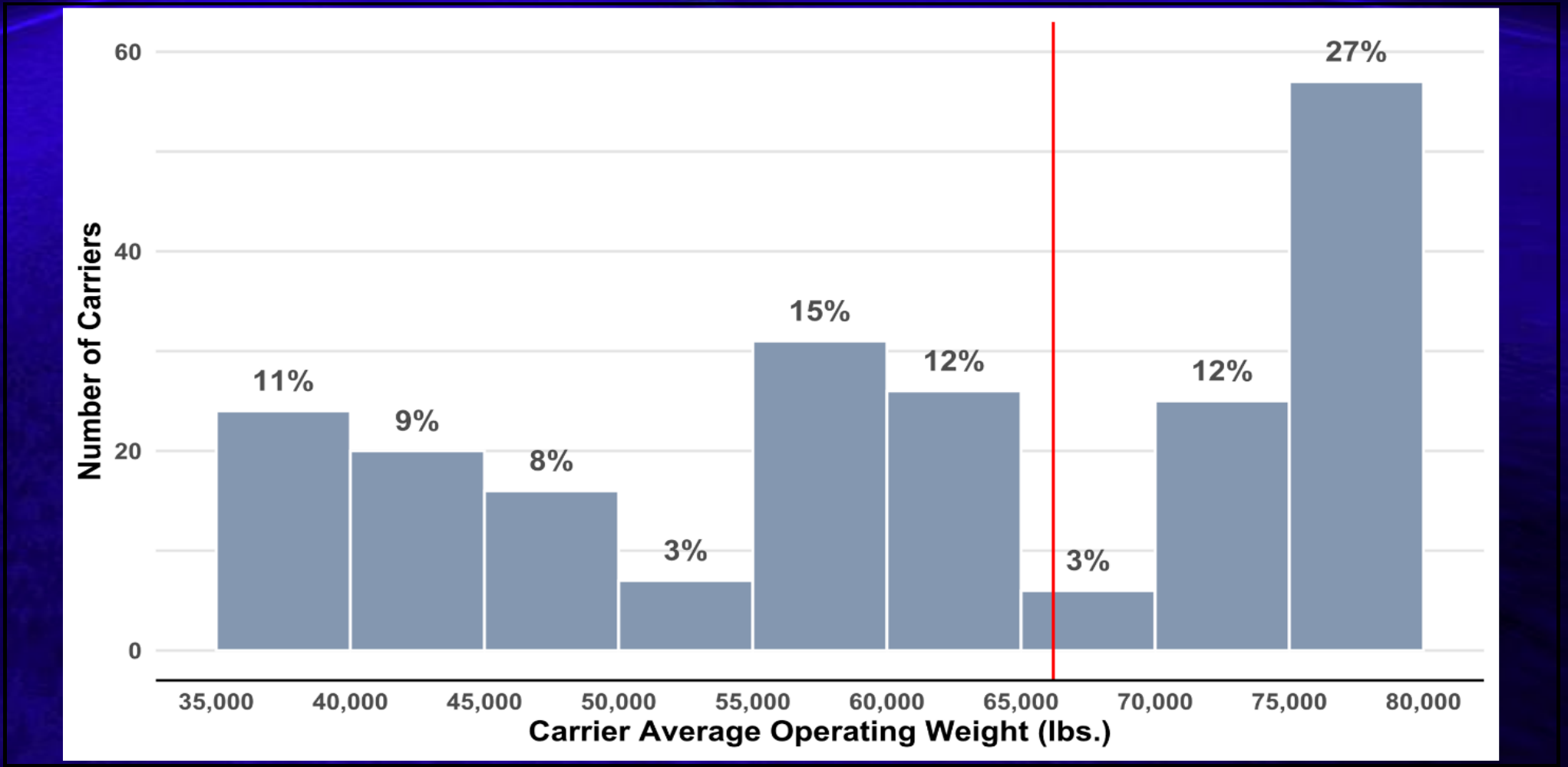
Cargo Analysis



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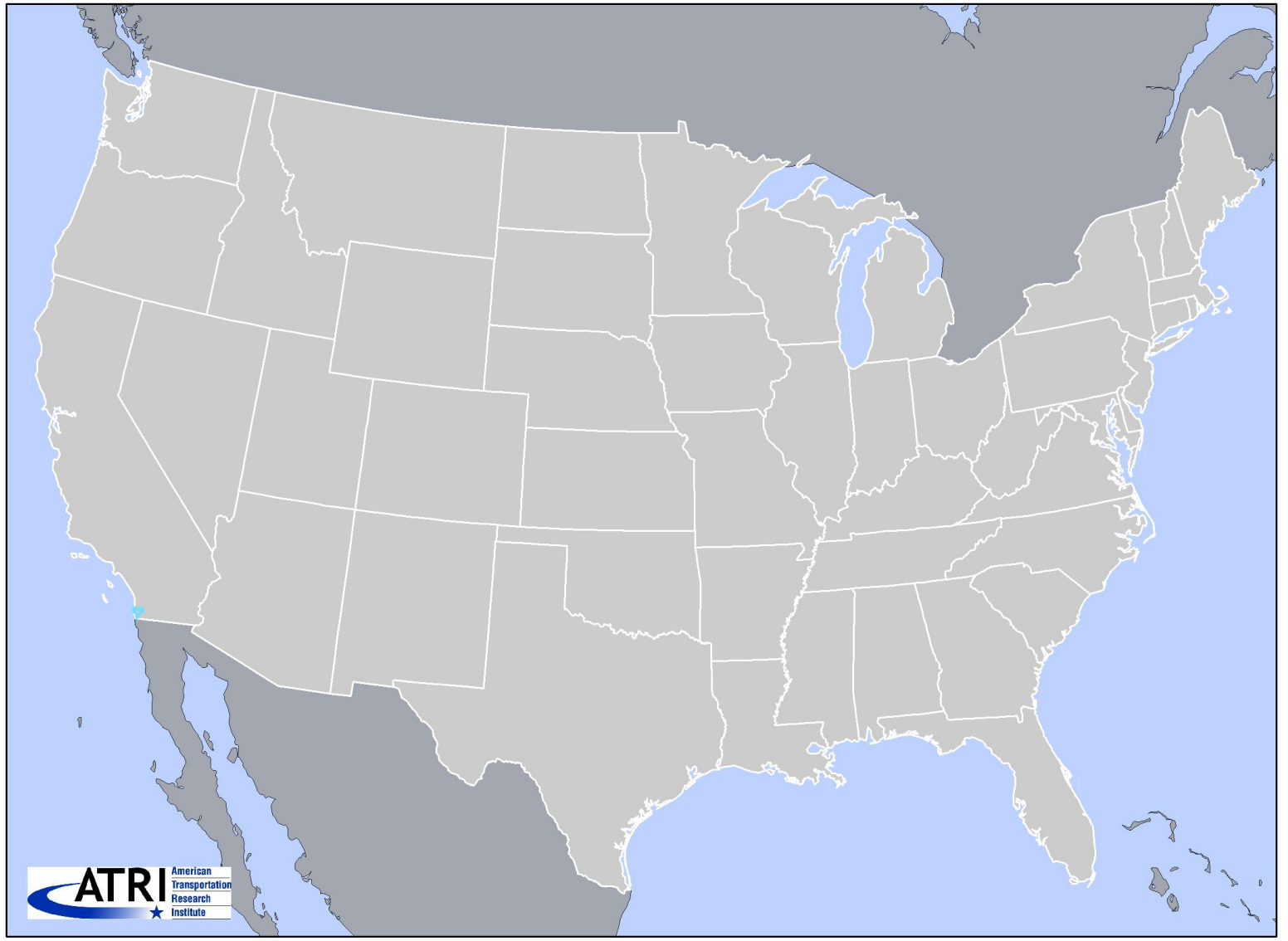
Charging Locations and the Impact on Operations



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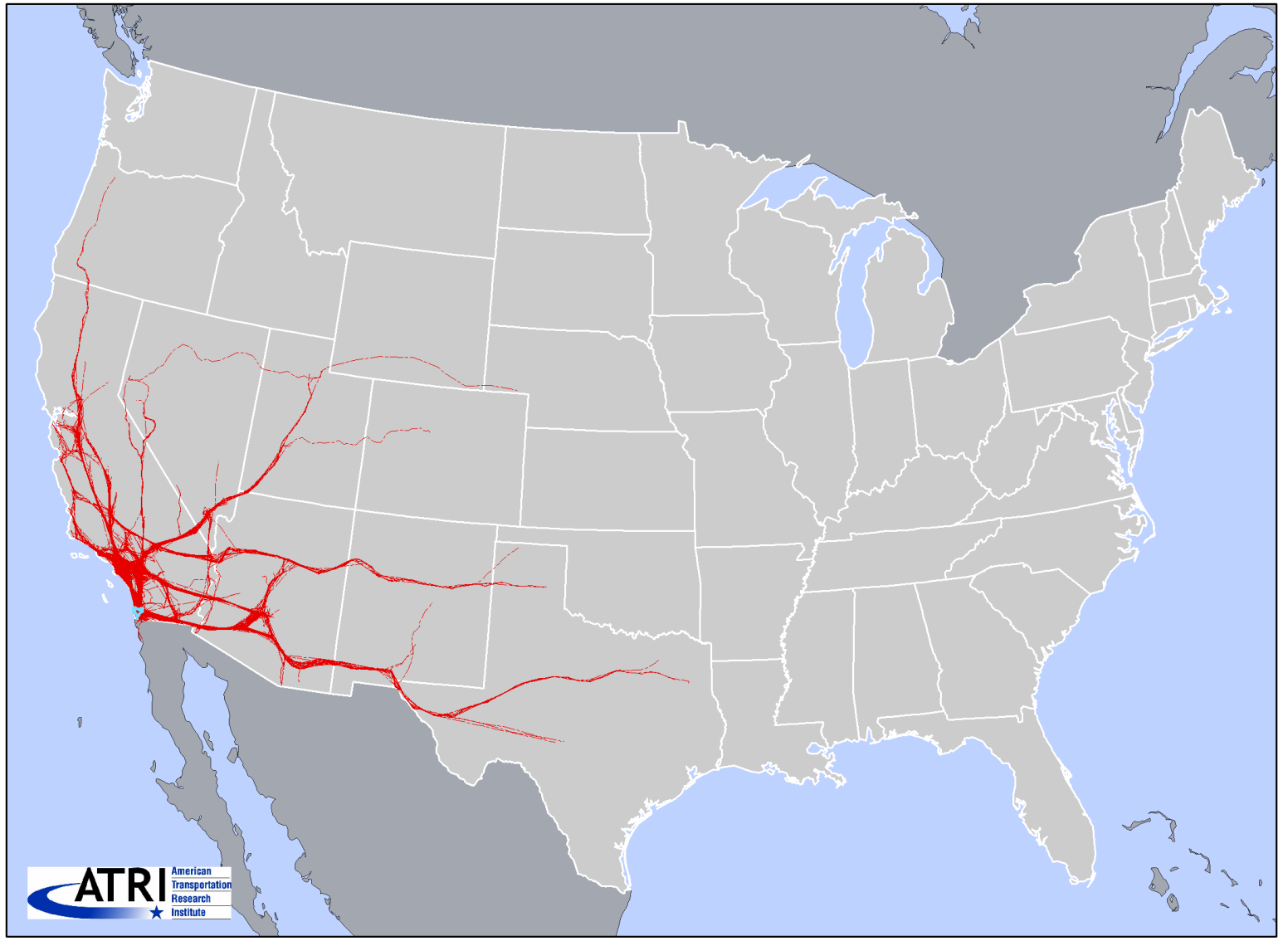
Same 2,000 Trucks After 24 Hours



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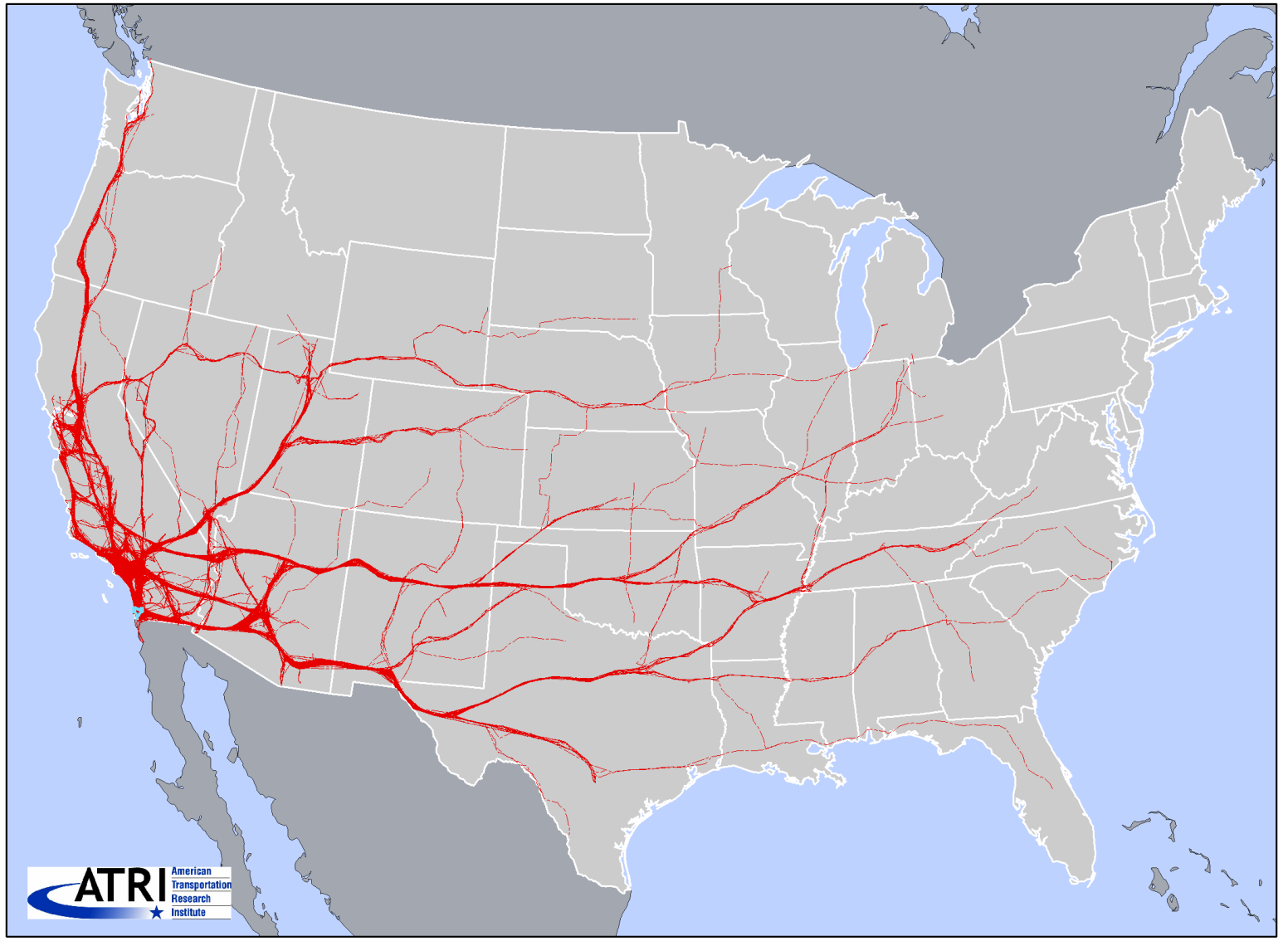
Same 2,000 Trucks After 48 Hours



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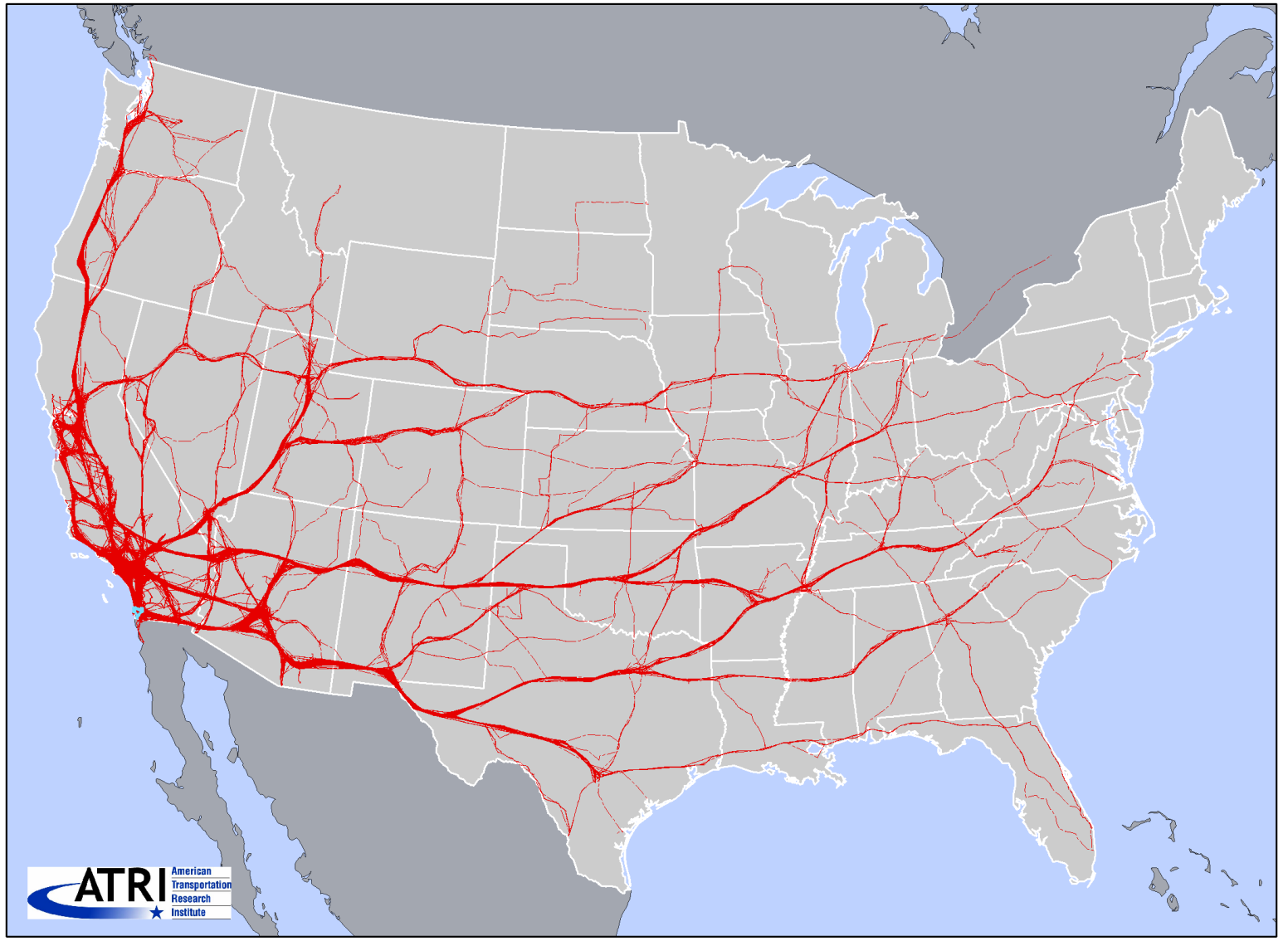
Same 2,000 Trucks After 72 Hours



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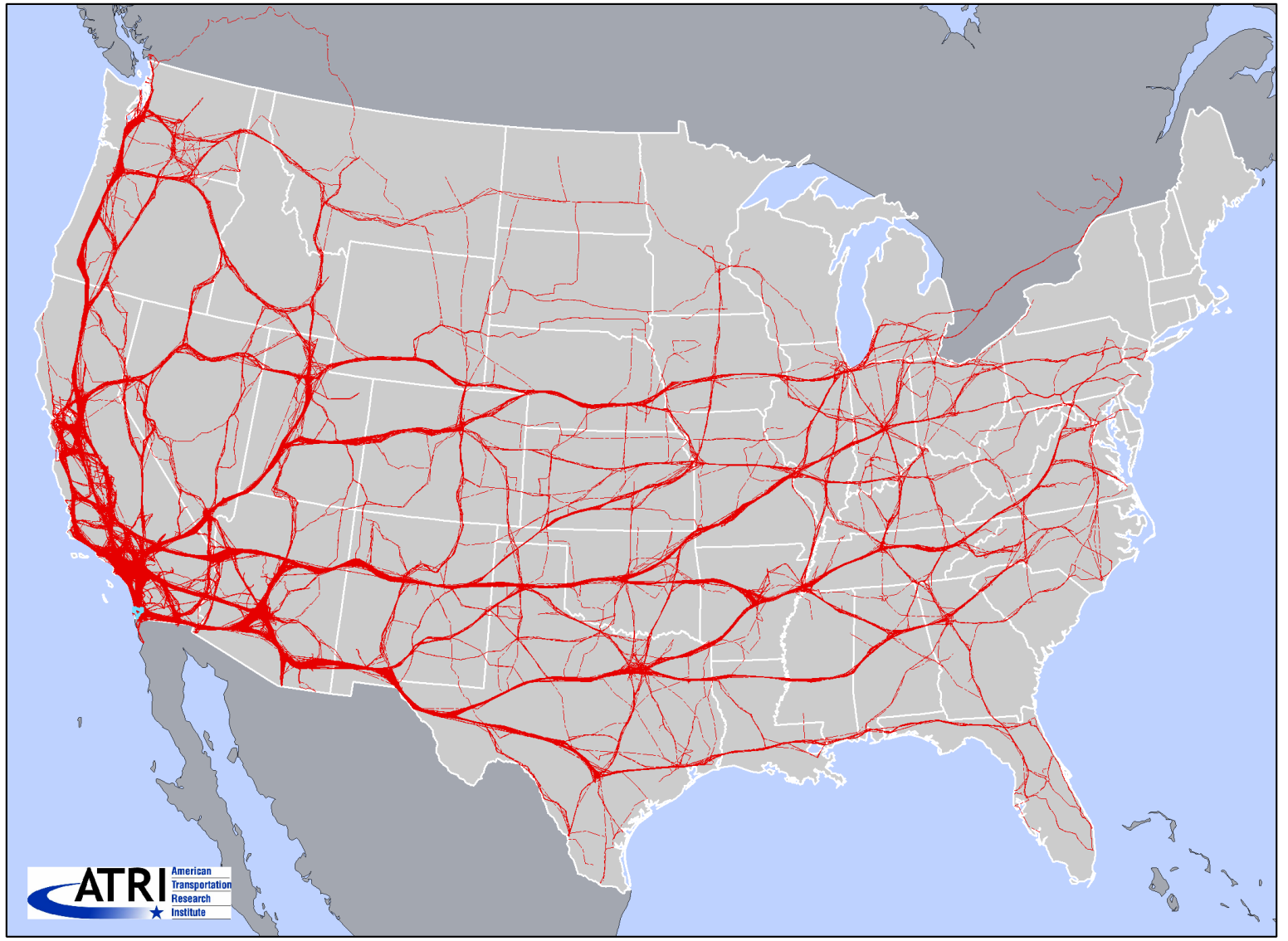
Same 2,000 Trucks After 5 Days



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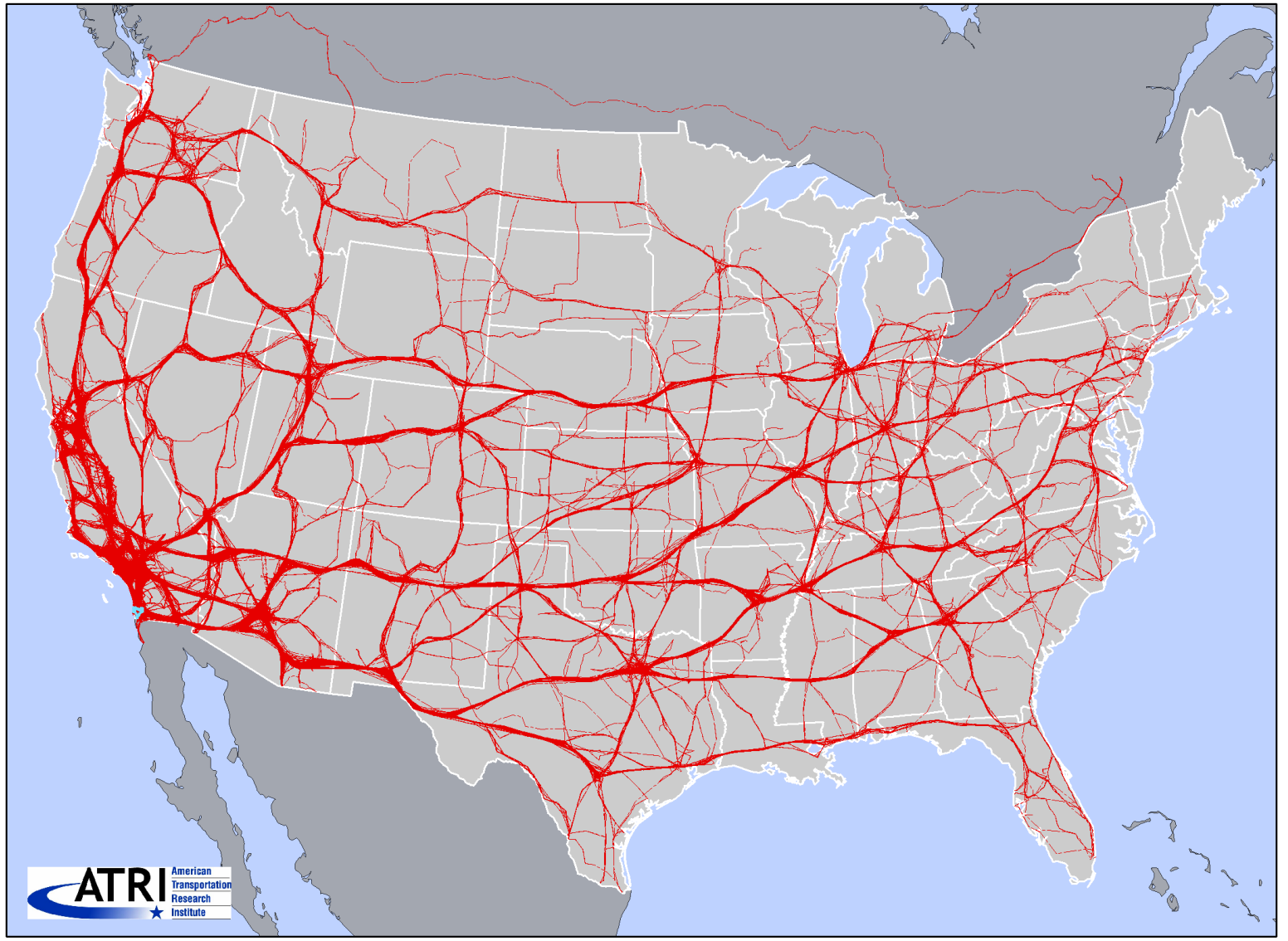
Same 2,000 Trucks After 7 Days



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Questions?

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