



CENTER FOR
AUTOMOTIVE
RESEARCH

The EV Transition

Electrification of the Automotive Industry

Dr. Andrew Brown Jr.

Chair – Center for Automotive Research
Board of Directors

Board Member – Ecumenical Theological Seminary
Chair – Presidential Selection Committee

October, 2024





WHAT WE DO

An independent nonprofit organization producing industry-driven research and fostering dialogue on critical issues facing the automotive industry and its impact on the U.S. economy and society.

RESEARCH

CAR helps you navigate the uncertain automotive environment through thought-provoking, independent, multi-disciplinary, and unbiased research and analysis of important industry trends and changes.

EVENTS

CAR hosts industry-driven events to disseminate key research, update stakeholders on critical issues, and foster discussions among thought leaders to share their insights and solutions to meet the challenges of an ever-evolving global automotive industry.

PROGRAMS

CAR fosters communication and support to promote the auto industry and the issues it faces today by bringing together communities, automakers, suppliers, and technology companies.

AGENDA

- **EV Transition**
- **Inflation Reduction Act**
- **IRA Impact**
- **EV Challenges**
- **United States-Mexico-Canada Agreement (USMCA)**



EV Transition

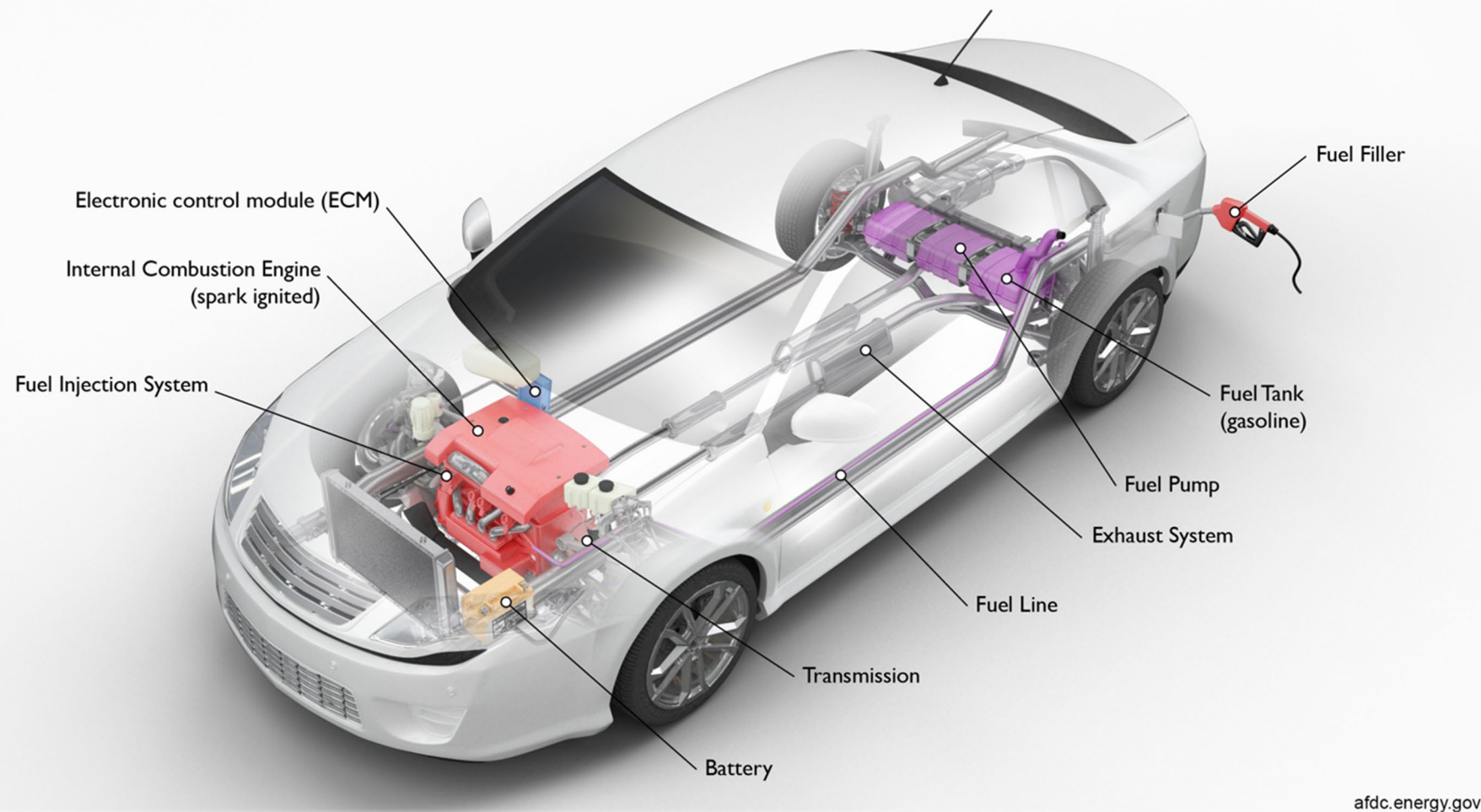




ICE to EV: Electrified Powertrain

Impact on Vehicle Components & Systems

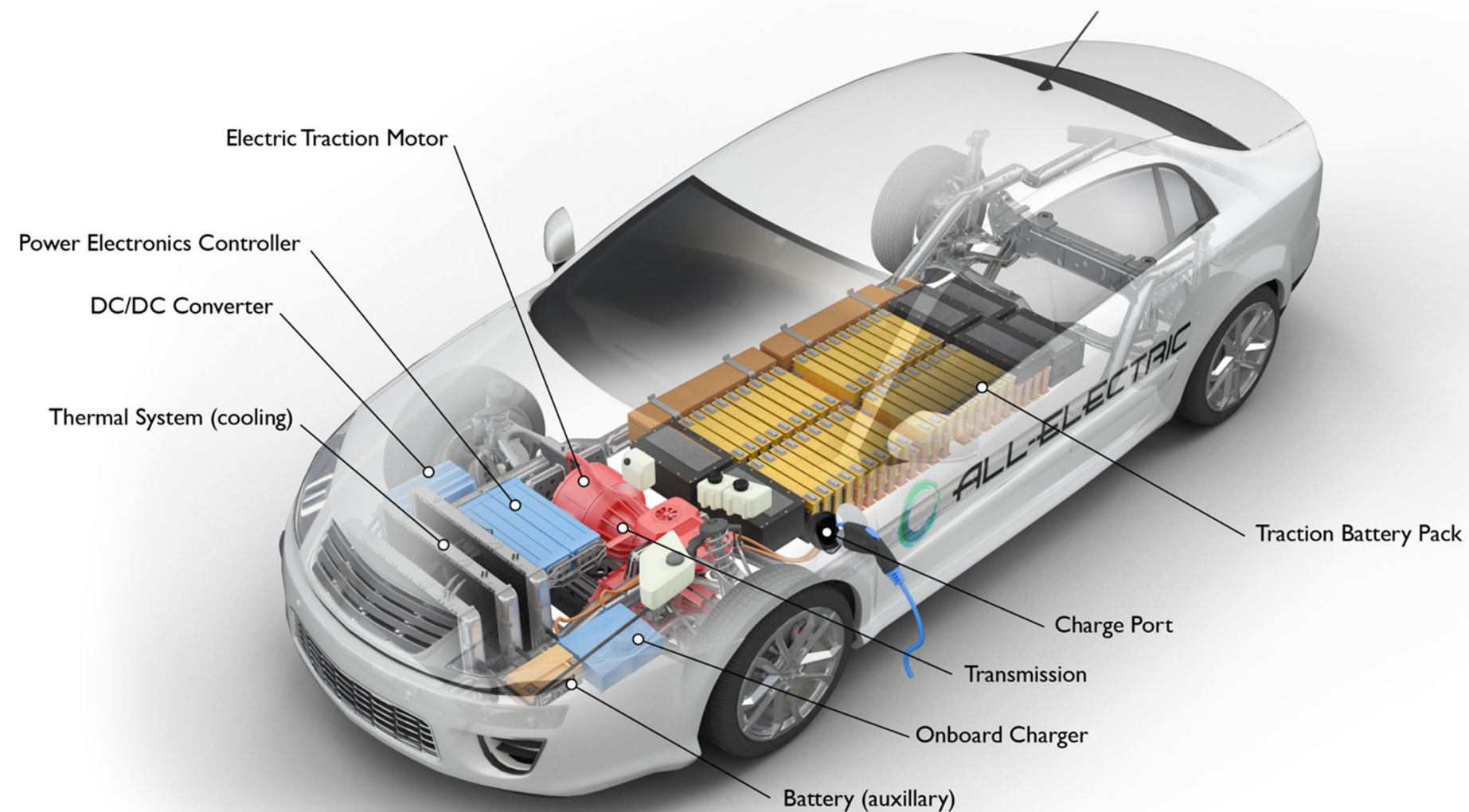
Gasoline Vehicle



EV systems added:

- Battery
- Electric Motor(s)
- Power Electronics

All-Electric Vehicle



ICE systems lost in transition:

- Engine
- Fuel Systems
- Exhaust Systems



The Electric Vehicle Transition

Implications of ICE to BEV Systems



Major Systems Affected by Transitioning to BEV

ICE Example Vehicle



×	Fuel system (Eliminated)
×	Exhaust system (Eliminated)
!	Axles, driveshafts & auxiliary components (Reduced content)
!	Clutches, planetary gears & torque converter replaced with electric drives
×	Engine (Eliminated)
+	Power electronics & high-voltage electrical architecture (Added)
+	Battery pack (Added)
+	Body structures (increased content), infotainment (upgraded), safety (upgraded), Climate Ctrl. (upgraded)

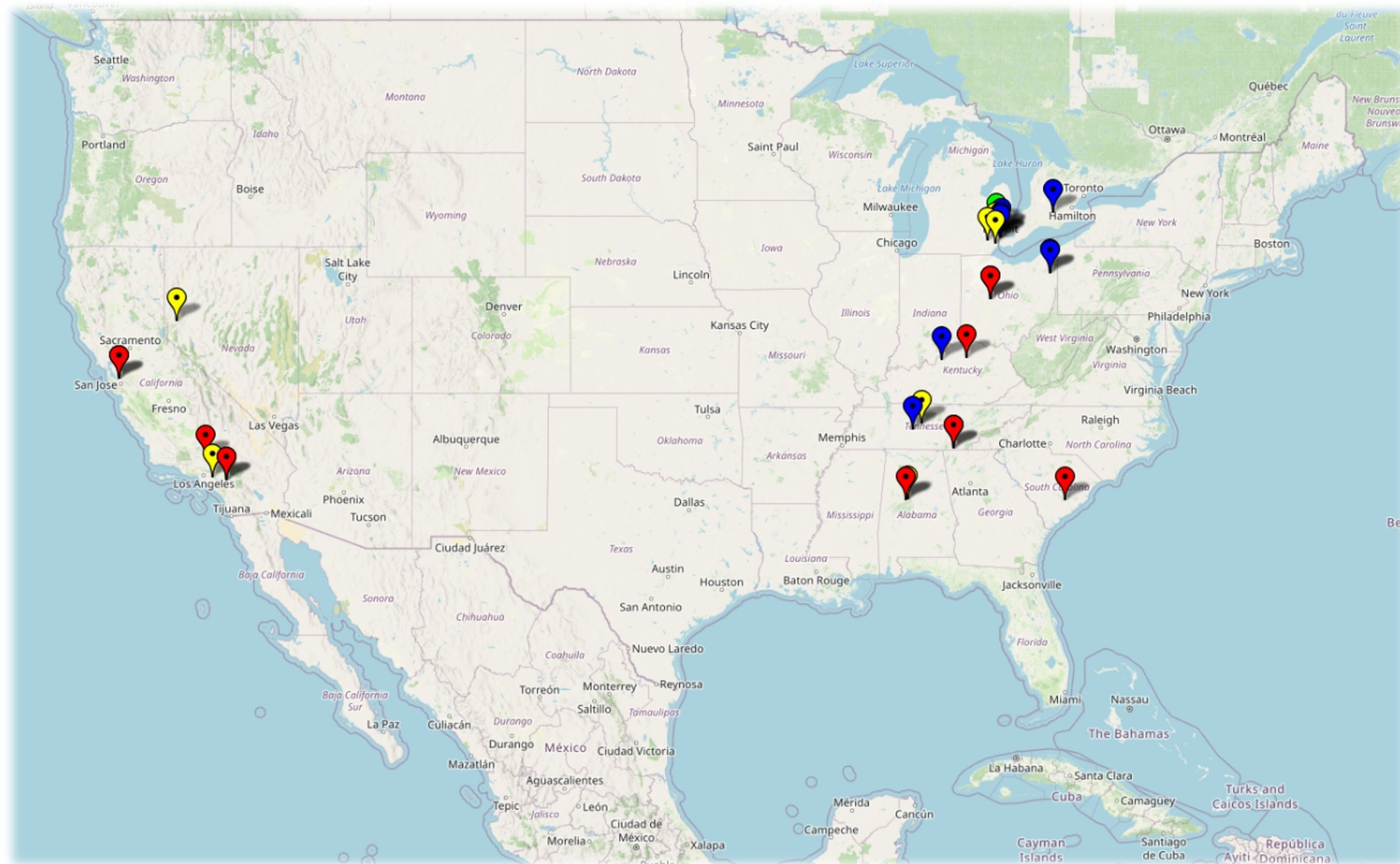
Est. Impact On Jobs	System Difference/ Role Changes
↓	<i>Displaced Employees</i>
↓	<i>Displaced Employees</i>
↓	DC/DC Converter + auxiliary battery
↓	Electric Traction Motor + Transmission
↓	<i>Displaced Employees</i>
↑	Power Electric Converter
↑	Traction Battery Pack, Charger, Charge Port
↑	Materials, In-Cabin Electronics, Safety systems, Thermal Control

Source: BofA Global Research, Intellicosting LLC, Wolfe Research & CAR analysis.



Major North America EV and Battery Investment Announcements by OEMs

Base: 2019



Investment Type

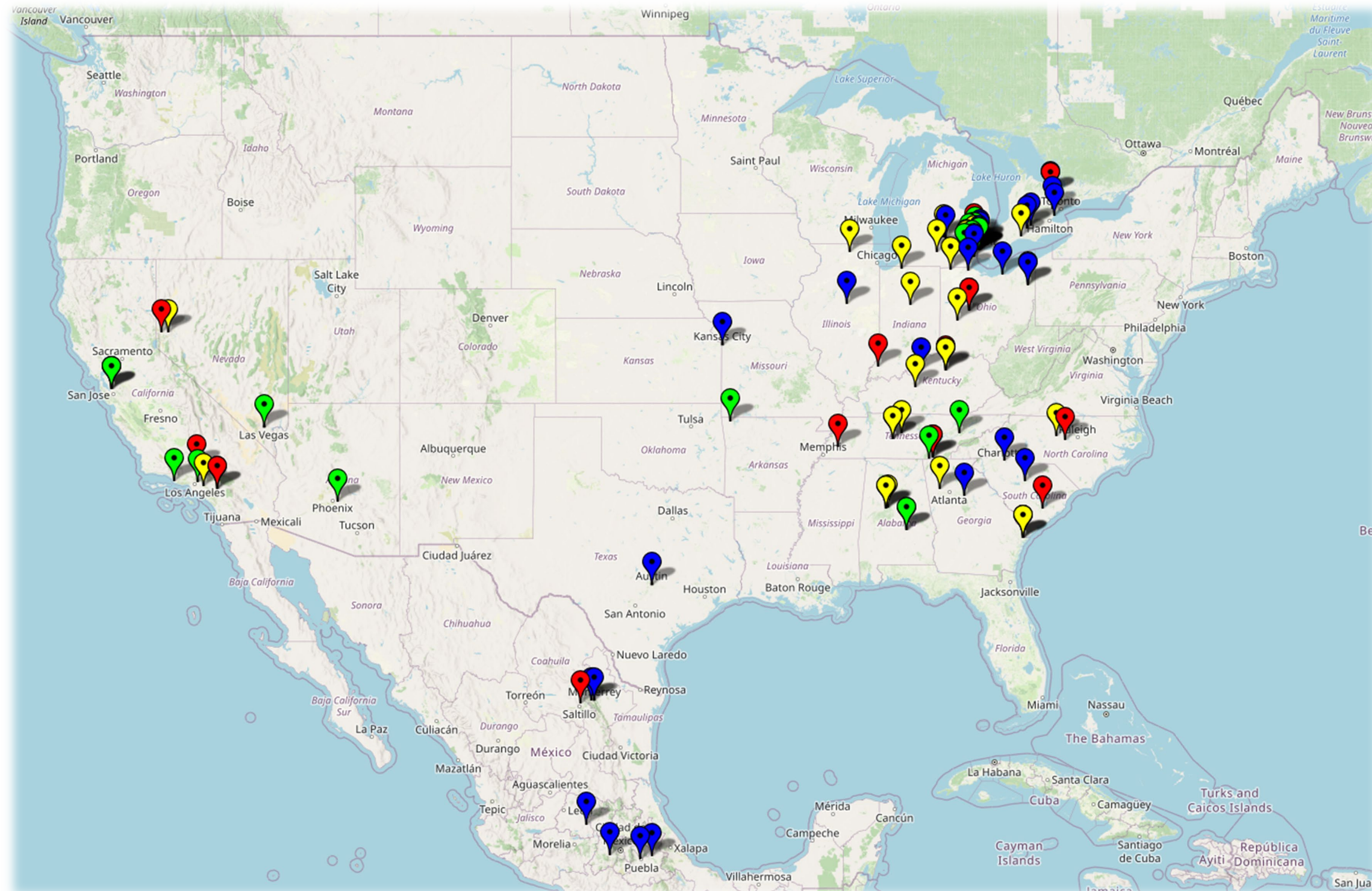
- Battery
- Electric Vehicle
- EV and Battery
- R&D

Source: CAR Book of Deals, GPS Visualizer

Note: Only Battery, Electric Vehicle, and EV and Battery announcements of over \$1.0 billion shown on map



Major North America EV and Battery Investment Announcements by OEMs 2019 – Q3 2024



Investment Type

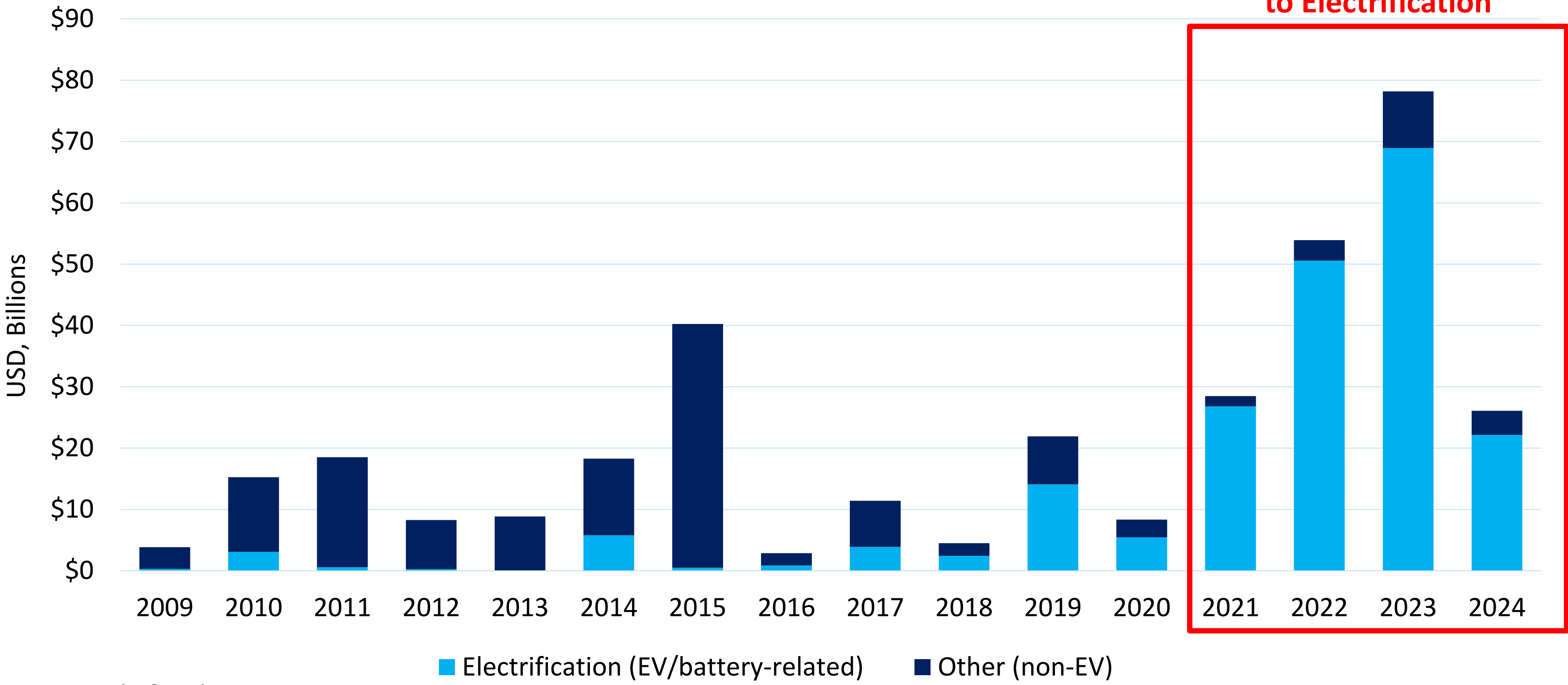
- Battery
- Electric Vehicle
- EV and Battery
- R&D

Source: CAR Book of Deals, GPS Visualizer

Note: Only Battery, Electric Vehicle, and EV and Battery announcements of over \$1.0 billion shown on map



Automaker Announced Investment North America, 2009 – Q3 2024



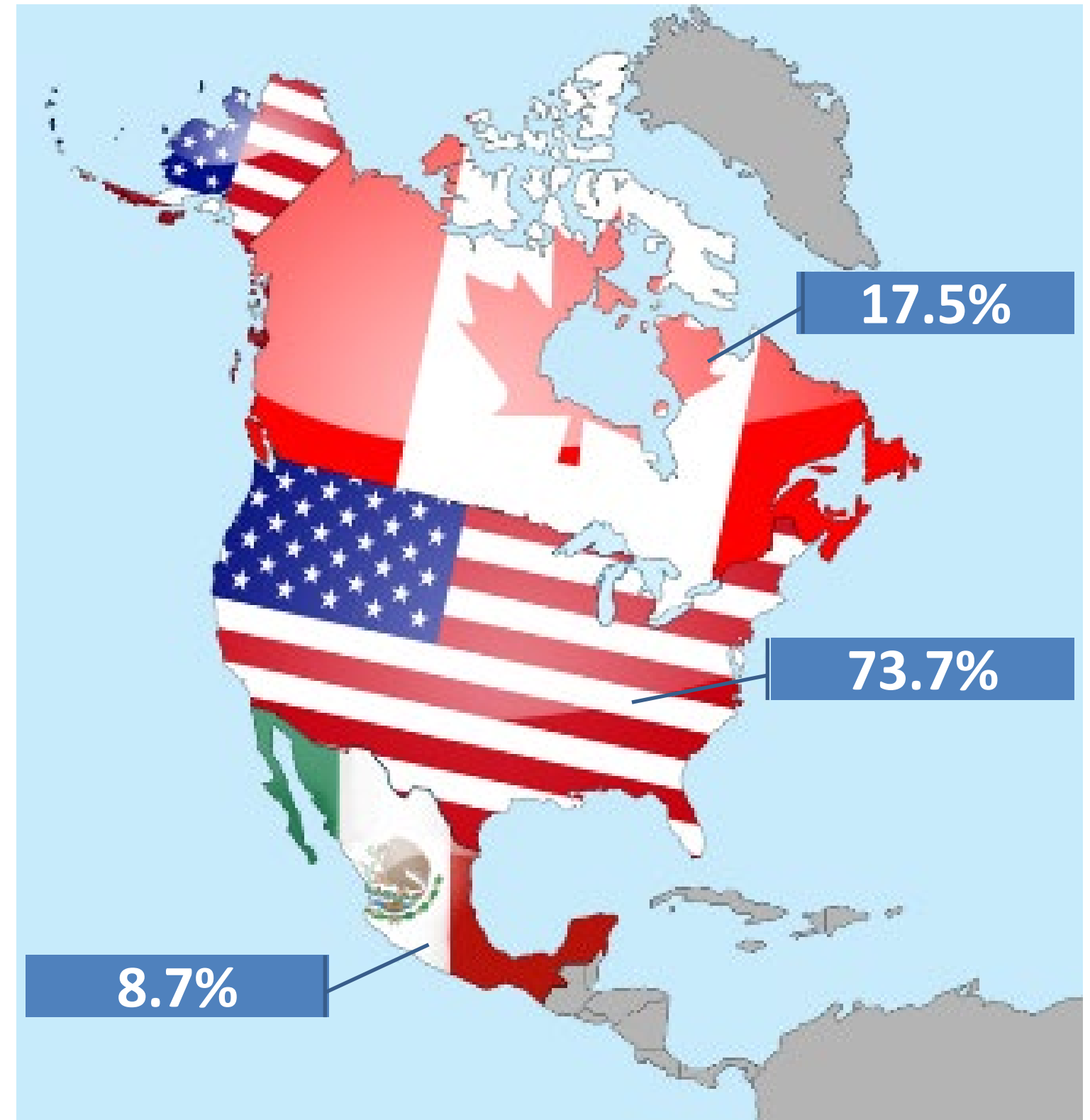
\$168 Billion linked to Electrification

Source: CAR Book of Deals, 2024



Automaker Announced Investment North America, 2018 – Q3 2024

Region	Investment Amount (\$USD)
Canada	\$38.9B
United States	\$163.3B
<i>U.S. Great Lakes</i>	\$82.6B
<i>U.S. South</i>	\$73.2B
<i>U.S. Other</i>	\$7.5B
Mexico	\$19.3B
Total	\$221.4B



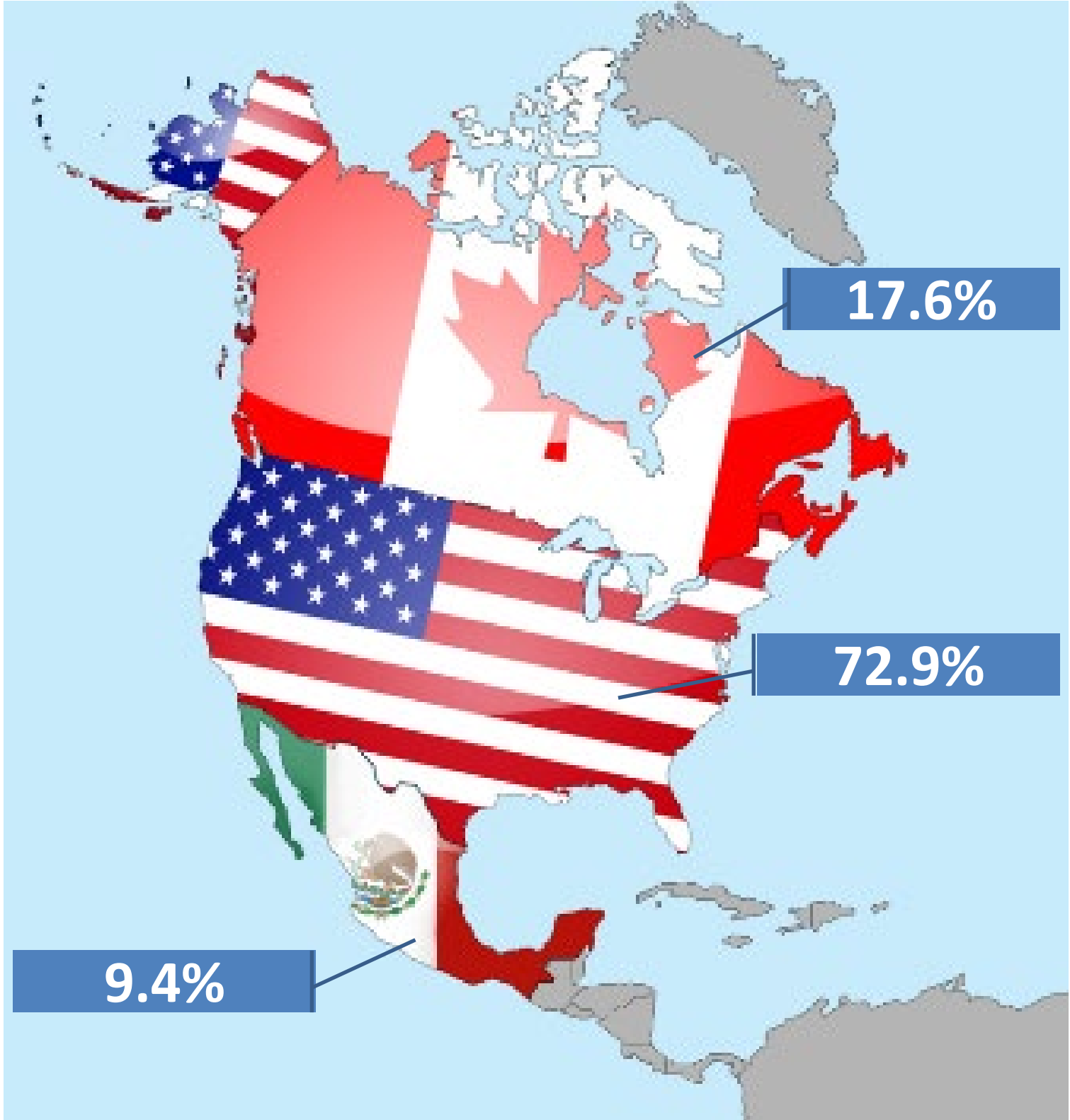
Note: U.S. Great Lakes includes: IL, IN, KY, MI, MO, and OH
U.S. South includes: AL, FL, GA, MS, NC, SC, TN, and TX



Automaker Announced EV/Battery-Related Investment

North America, 2018 – Q3 2024

Region	Investment Amount (\$USD)
Canada	\$33.6B
United States	\$138.9B
<i>U.S. Great Lakes</i>	\$66.5B
<i>U.S. South</i>	\$67.1B
<i>U.S. Other</i>	\$5.3B
Mexico	\$18.0B
Total	\$190.5B

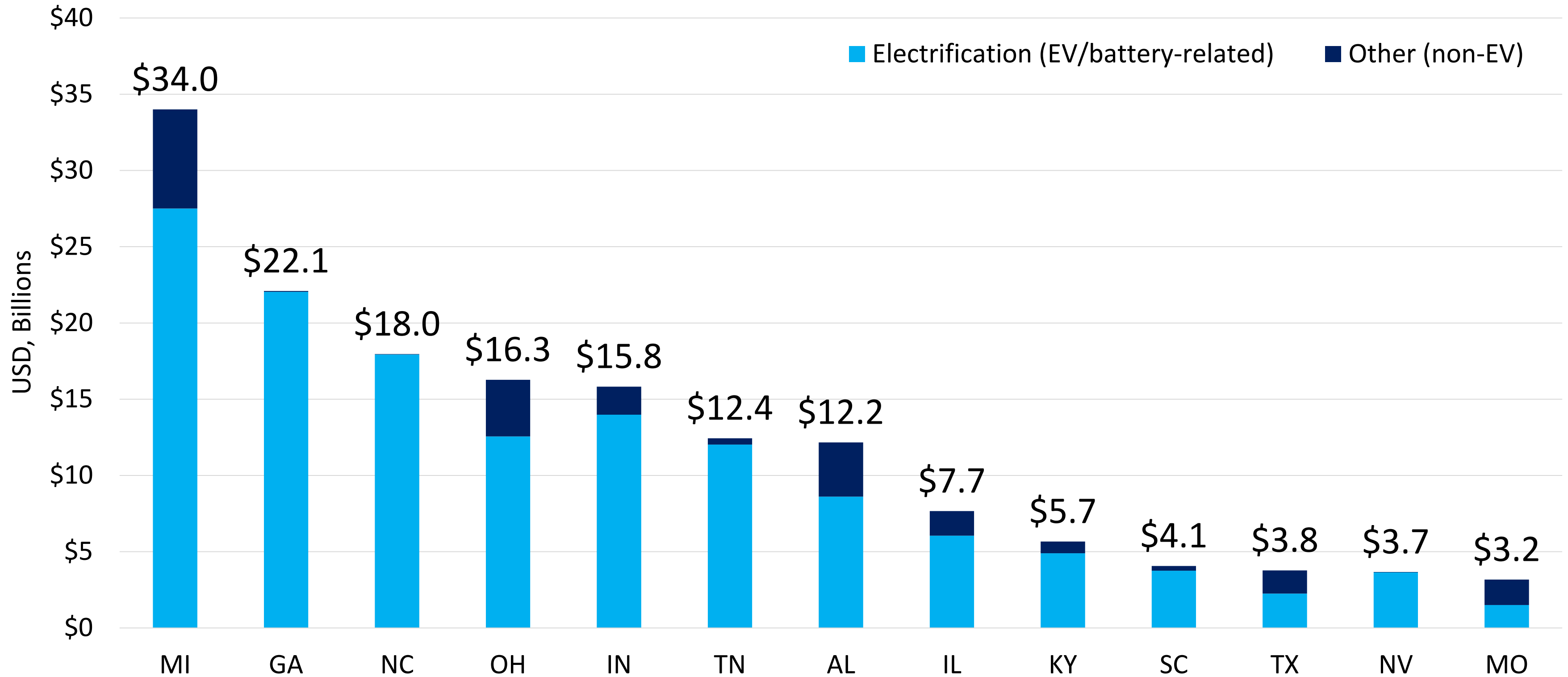


Note: U.S. Great Lakes includes: IL, IN, KY, MI, MO, and OH
 U.S. South includes: AL, FL, GA, MS, NC, SC, TN, and TX



Automaker Announced Investment

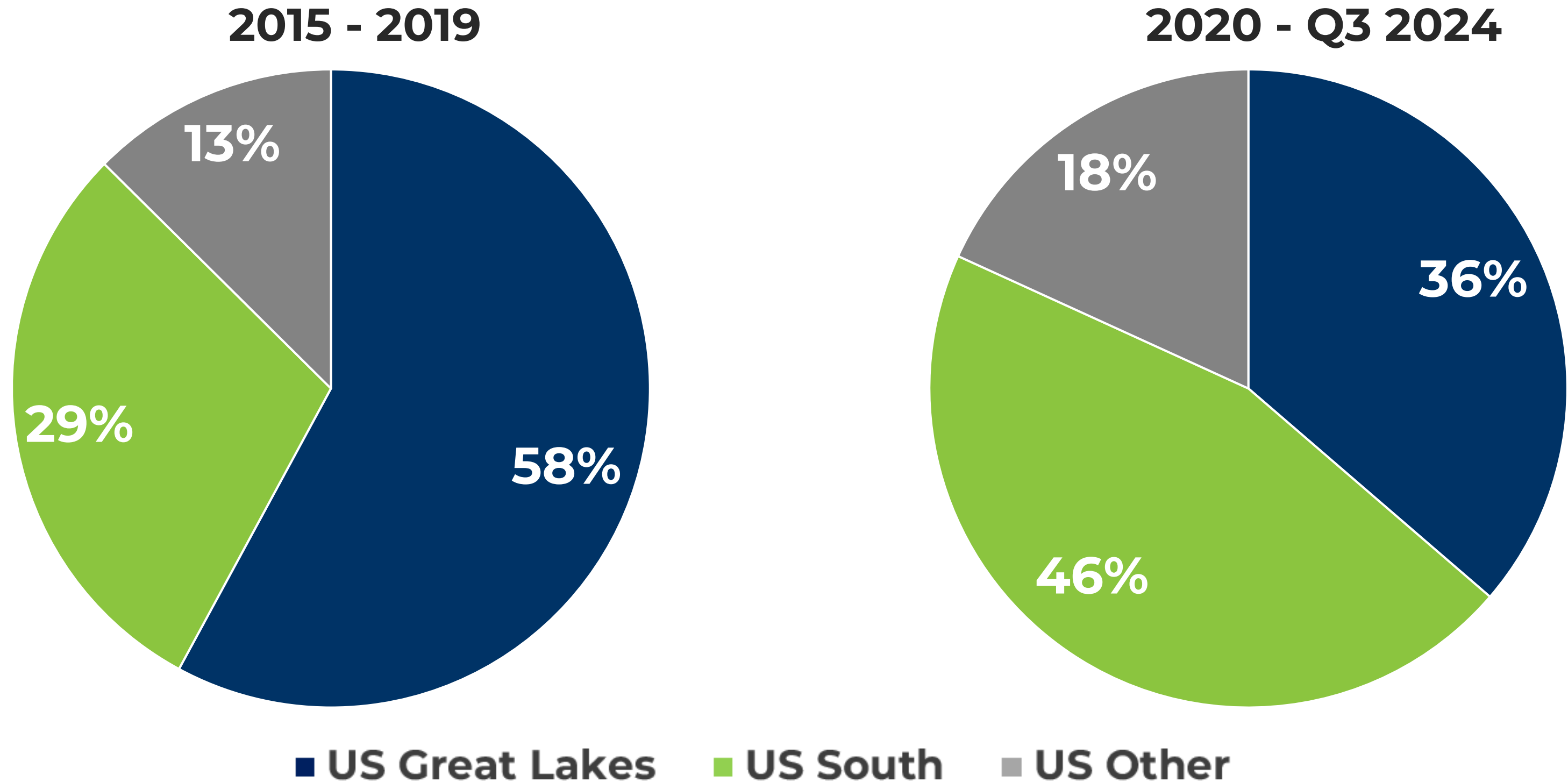
United States, 2018 – Q3 2024, 85% EV/Battery-Related



Source: CAR Book of Deals, 2024



Automotive announced investment migrates South in the EV transition



Note: U.S. Great Lakes includes: IL, IN, KY, MI, MO, and OH
U.S. South includes: AL, FL, GA, MS, NC, SC, TN, and TX



Inflation Reduction Act





Inflation Reduction Act

- **Clean Vehicle Credit**
- **Previously-Owned Clean Vehicles**
- **Credit for Qualified Commercial Clean Vehicles**
- **Advanced Manufacturing Production Credit**

Clean Vehicle Credit (New Vehicles)

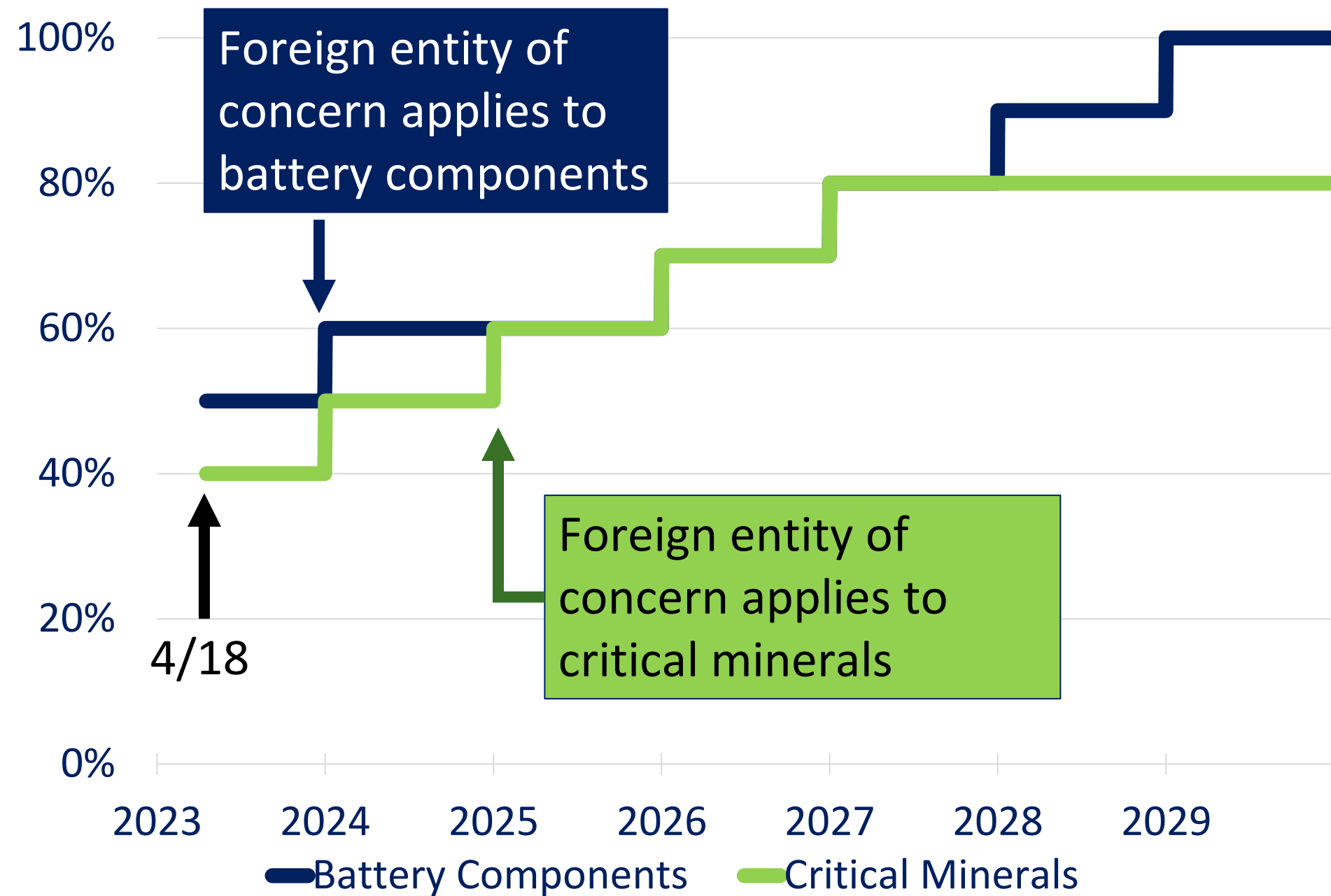
- **Must be made in North America**
- **Light-duty vehicle only (under 14,000 lbs.)**
- **Up to \$7,500 per new vehicle**
- **Income and MSRP provisions applied**
- **Critical mineral and battery component provisions applied 4/18/23**
- **Foreign entity of concern restriction applied (2024, 2025 and after)**
- **Available through 2032. No quota limit**







Clean New Vehicle Credit

Sourcing and MSRP requirements

Share of NA Value
(NA+FTA for minerals)



Vehicle Type	MSRP Cap
 Van	<\$80,000
 Sport Utility Vehicles	<\$80,000
 Truck	<\$80,000
 Passenger Vehicles	<\$55,000



Inflation Reduction Act

- Clean Vehicle Credit
- **Previously-Owned Clean Vehicles**
- Credit for Qualified Commercial Clean Vehicles
- Advanced Manufacturing Production Credit

Previously-Owned Clean Vehicles Credit

- Up to \$4,000 credit
- Must be purchased through a qualified auto dealer
- Income provision applied
- Vehicle price < \$25,000

Credit for Qualified Commercial Clean Vehicles

- Light-duty vehicles up to \$7,500
- Rental and leased vehicles qualify
- No income, MSRP, battery, or critical mineral provisions
- No foreign entity of concern provision
- Vehicles made outside of NA qualify



Inflation Reduction Act

- Clean Vehicle Credit
- Previously-Owned Clean Vehicles
- Credit for Qualified Commercial Clean Vehicles
- **Advanced Manufacturing Production Credit**

Advanced Manufacturing Production Credit

- Credit is refundable
- Battery Cell – \$35 per kWh
- Battery Module – \$10 per kWh
- Battery Module not using cells – \$45 per kWh
- Electrode Active Materials – 10% of production cost

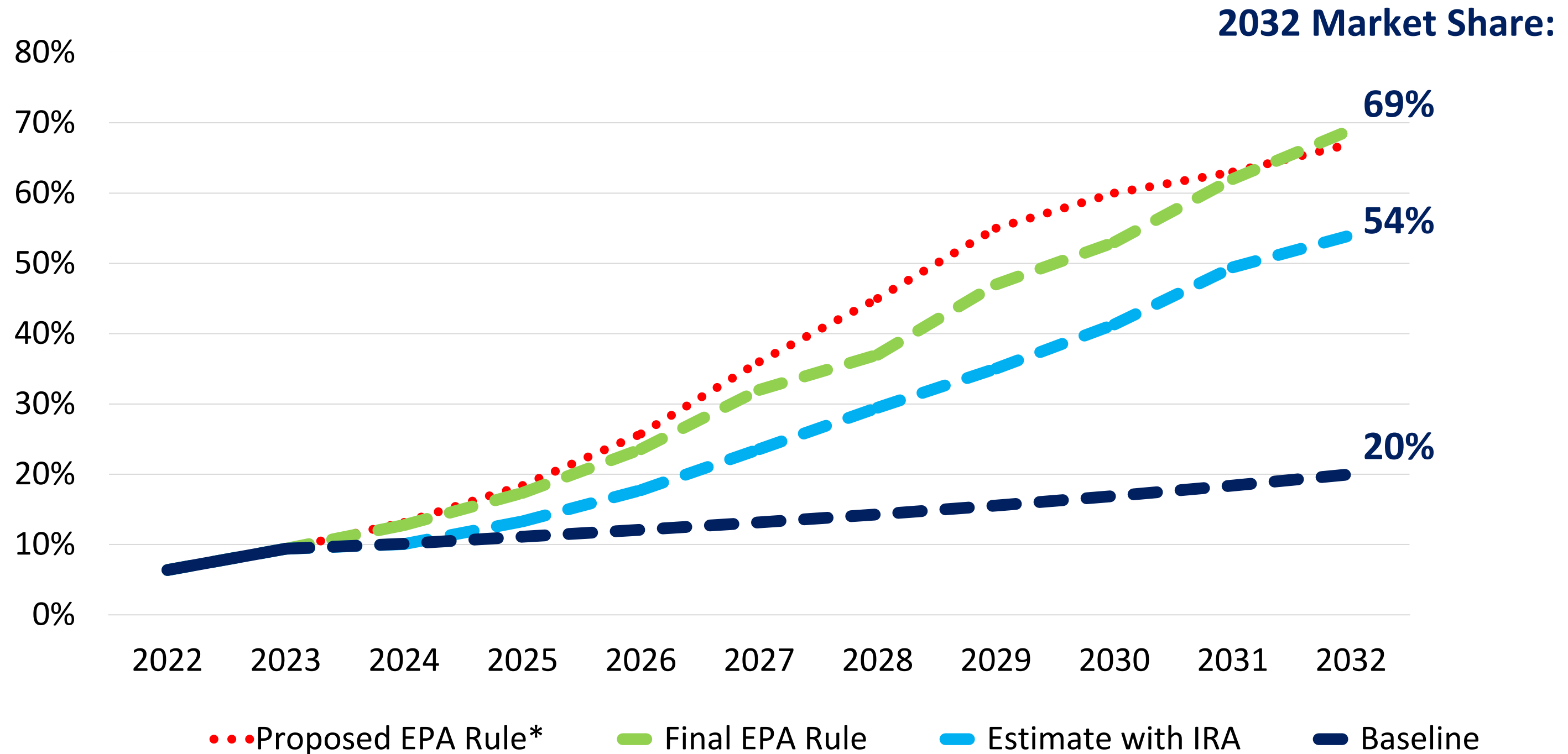


IRA Impact





U.S. BEV and PHEV Market Share Projections 2022-2023 Actual; 2024 – 2032 Forecast





Electrification: Labor Impact

Lost ICE jobs offset by gains in electrification

Manufacturing Job Losses

- Engines and Engine Parts
- Transmissions
- Fuel Systems
- Assembly (fewer parts)

Manufacturing Job Growth

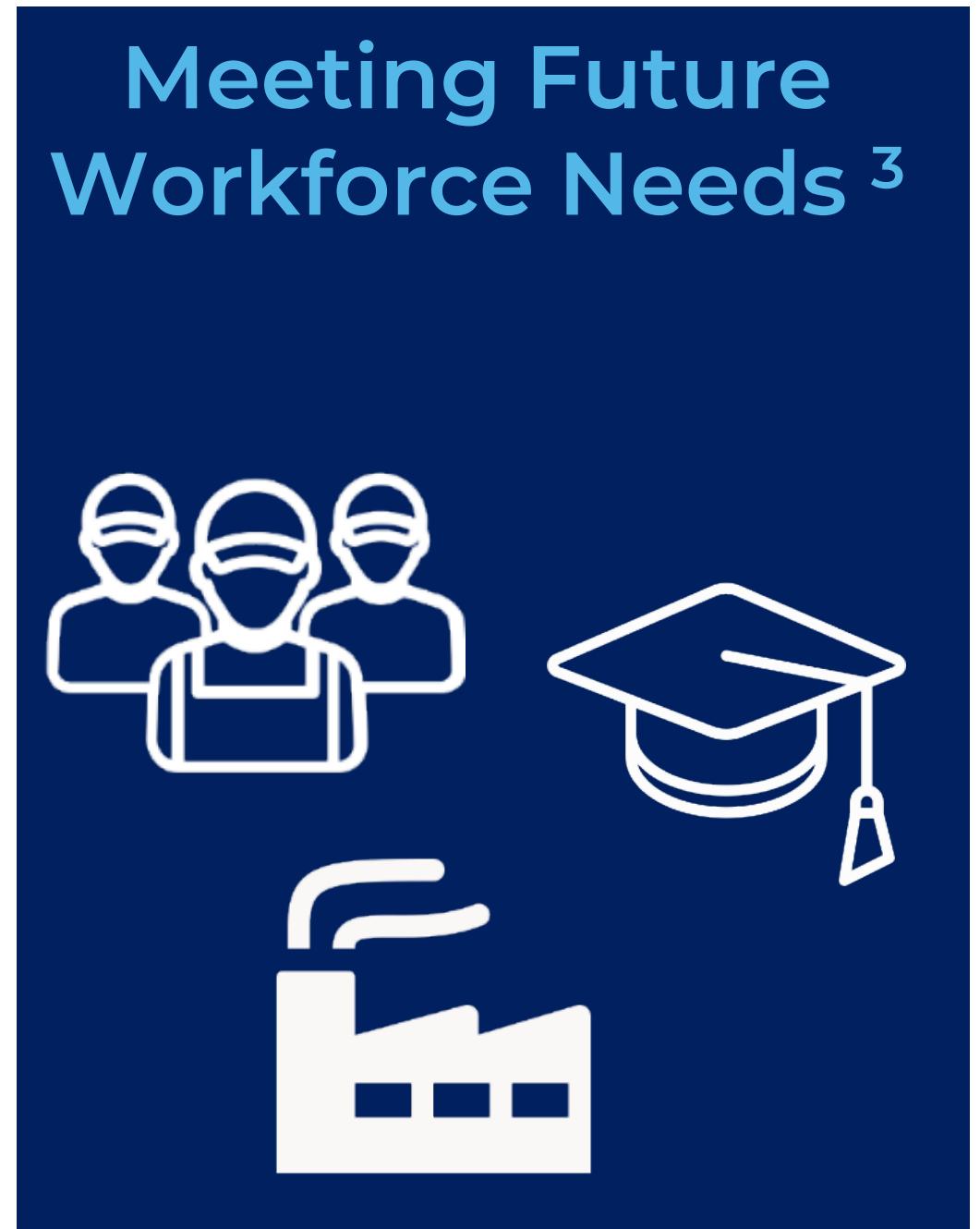
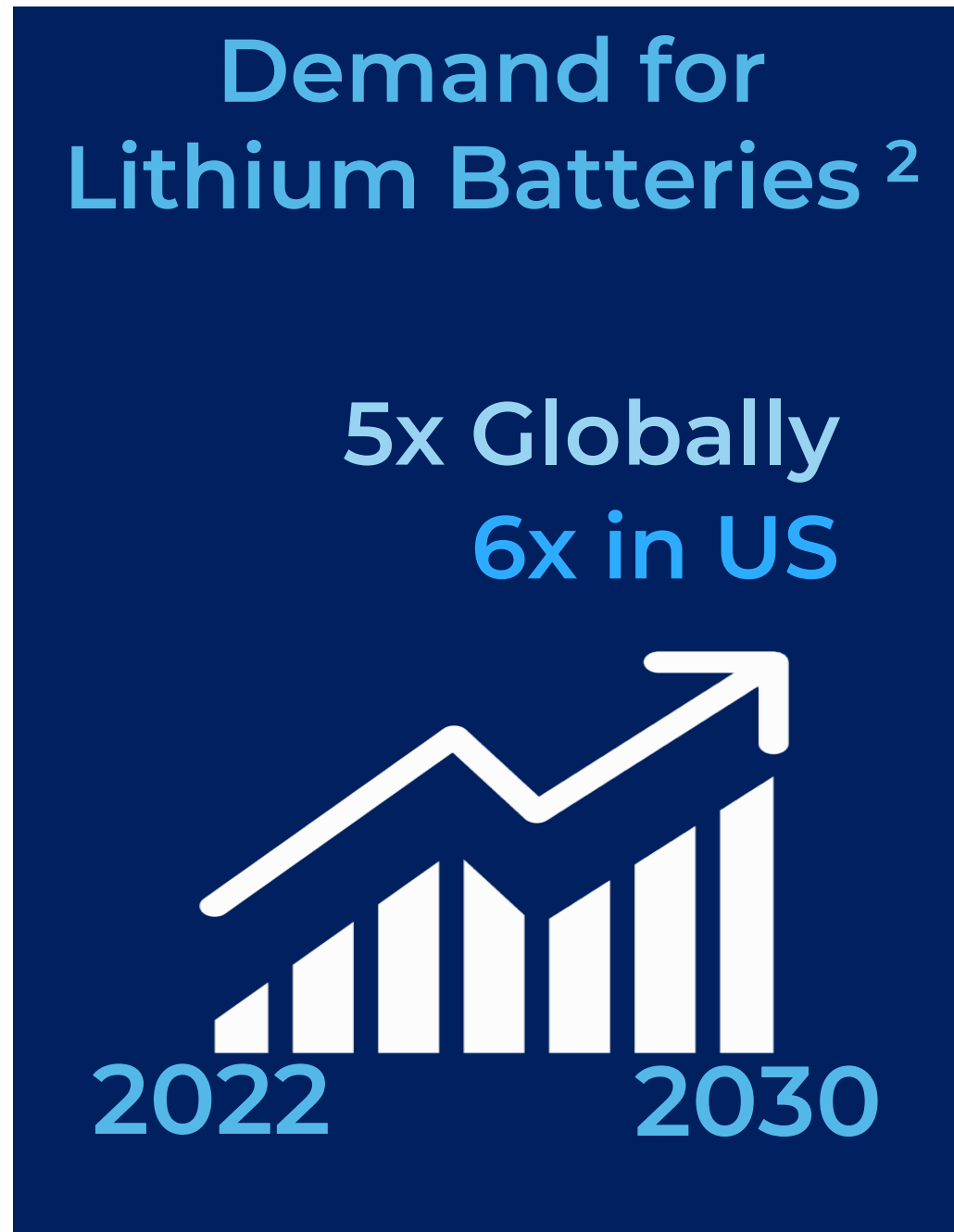
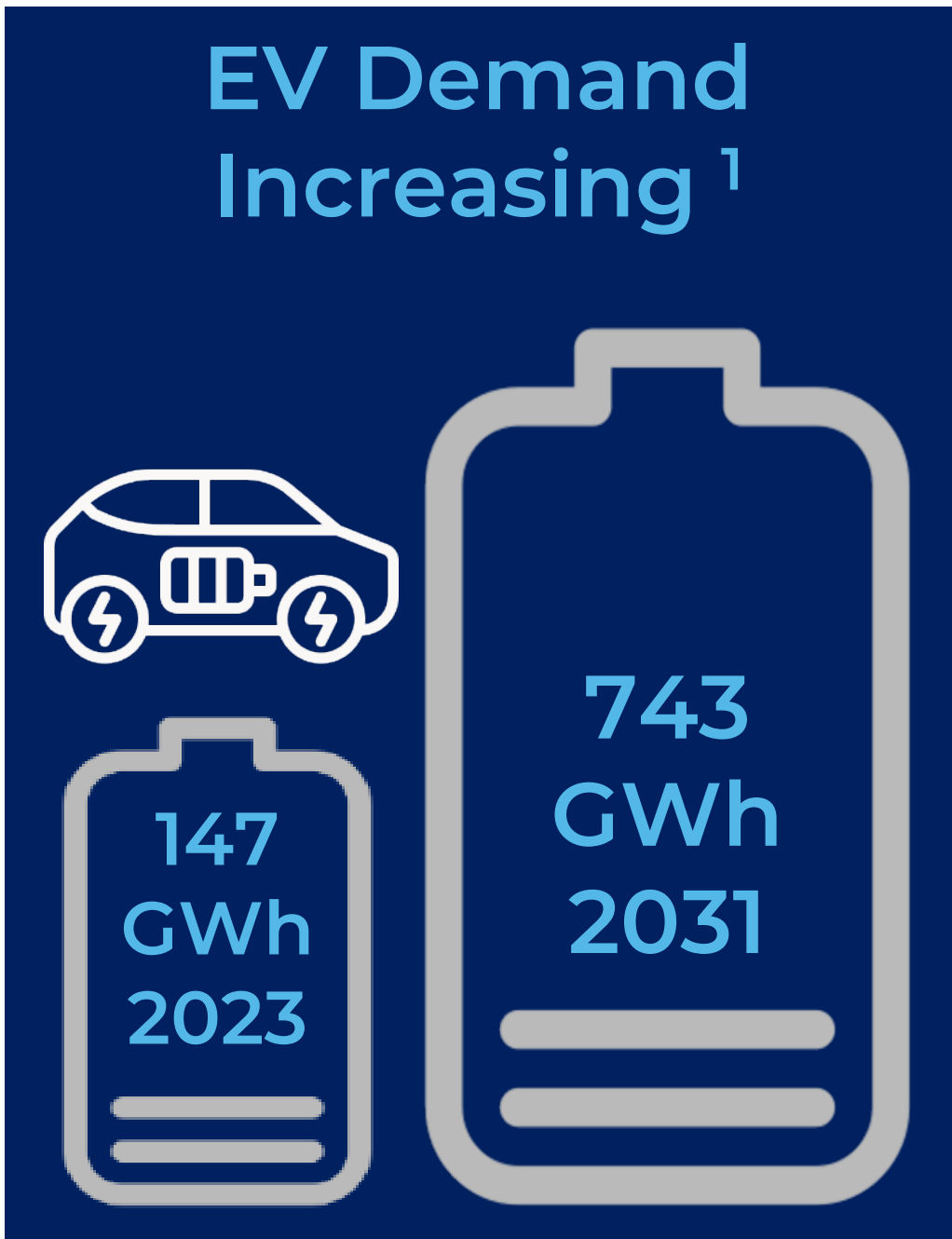
- E-axles and E-motors
- Battery Packs and Modules
- Electrical Installation (EV Infrastructure)
- Increased Assembly Complexity due to Increased Electronics

ICE manufacturing job losses can be offset by growth in electrification jobs. The number of roles may not be reduced overall but many current automotive manufacturing workers may need to be reskilled to fill new roles.



Impacts of Increasing EV Demand

Current State of US Battery Industry



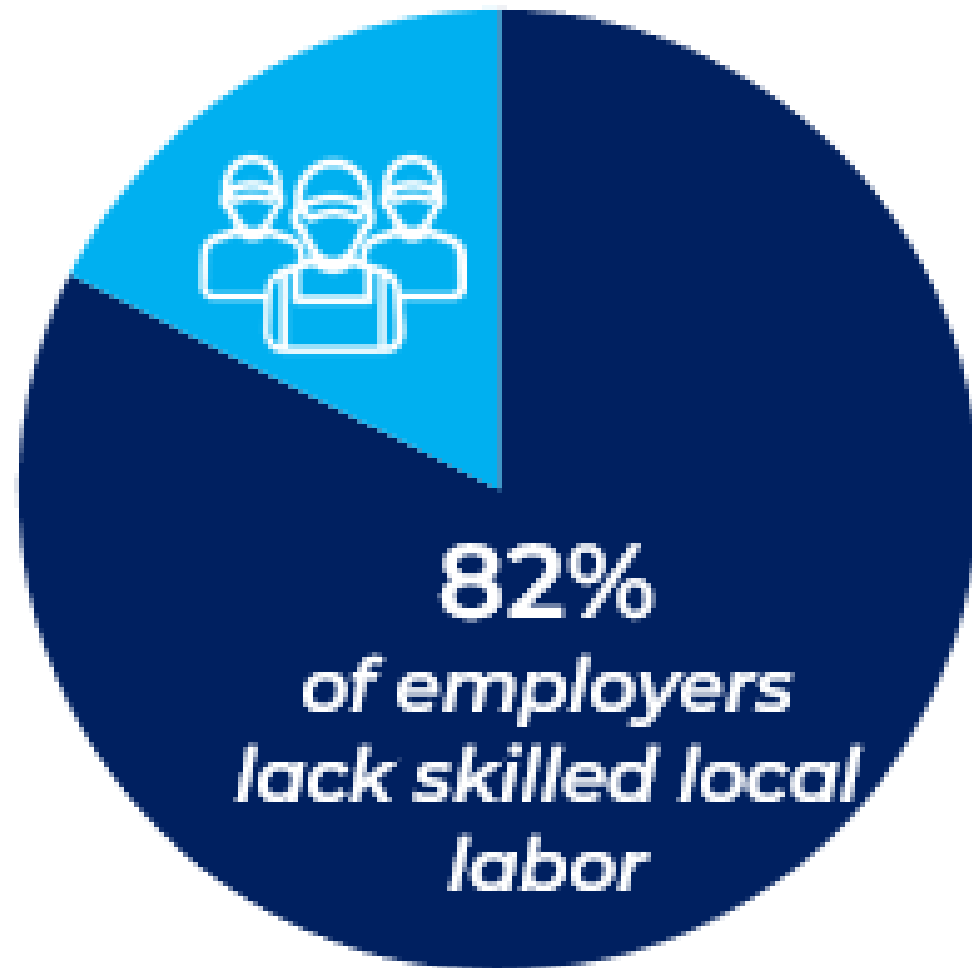
¹ Li Bridge Report; ²BCG Analysis; ³Upjohn Report (2024)



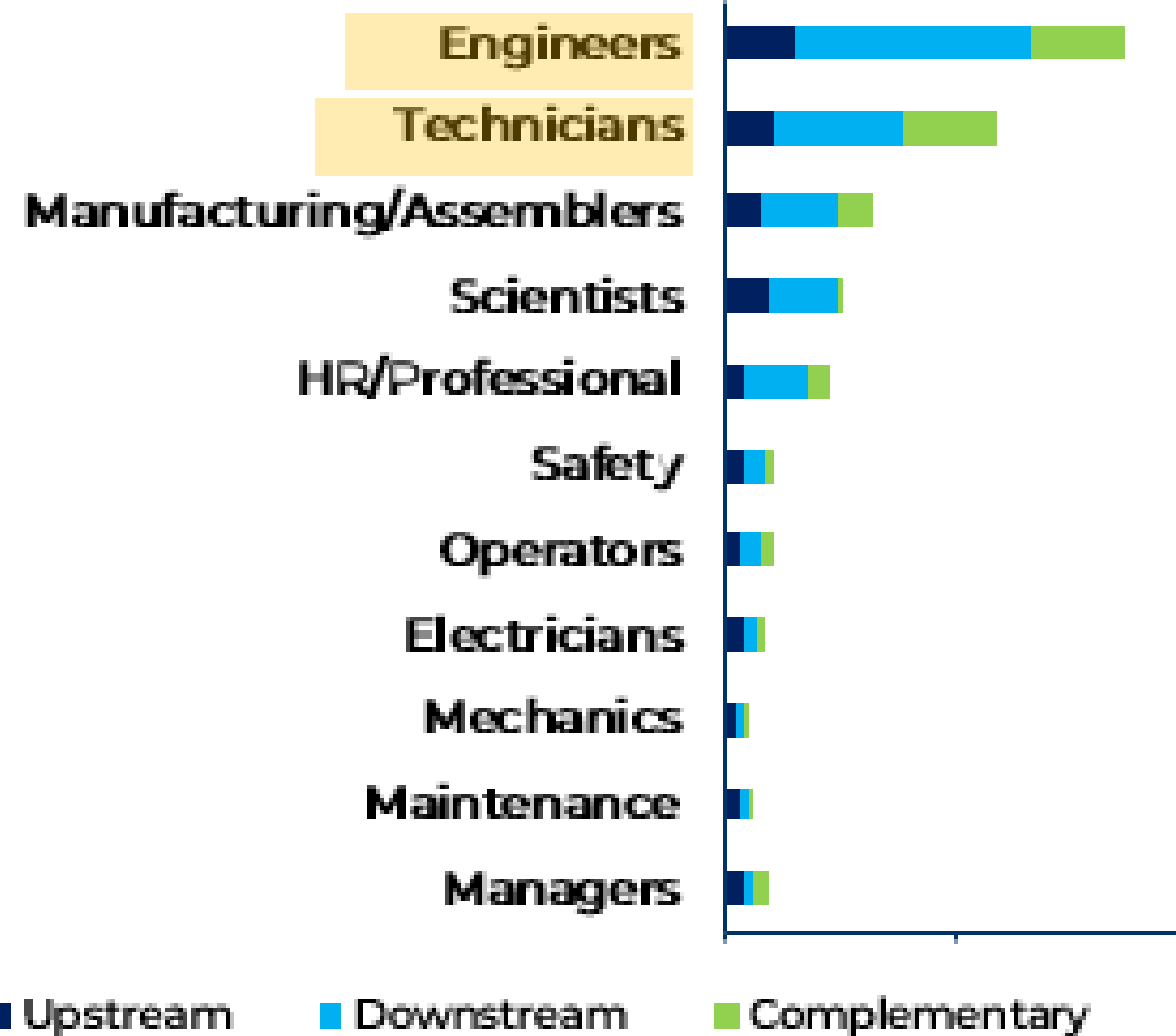
BIETNA Findings

Workforce Shortages and Retention Challenges

WORKFORCE SHORTAGES



ROLES IN SHORT SUPPLY



RETENTION CHALLENGES

- Competition with other industries
- Lack of experienced leaders and SMEs
- Geographic location/ cost of living
- Shift work
- Turnover due to high demand



To download a copy of the
CAR BIETNA report, visit:

www.cargroup.org/bietna



CENTER FOR
AUTOMOTIVE
RESEARCH

Examining Workforce
Needs for North America:
Battery Industry
Education and Training
Needs Assessment
(BIETNA)

Lisa Krusemark
Snehasis Ganguly
Tyler Harp
Alex Kulicki
Cullen Smith
K. Venkatesh Prasad

2024

Pre-Publication Copy

*Under review by Argonne National Laboratory
and the Department of Energy*



EV Challenges

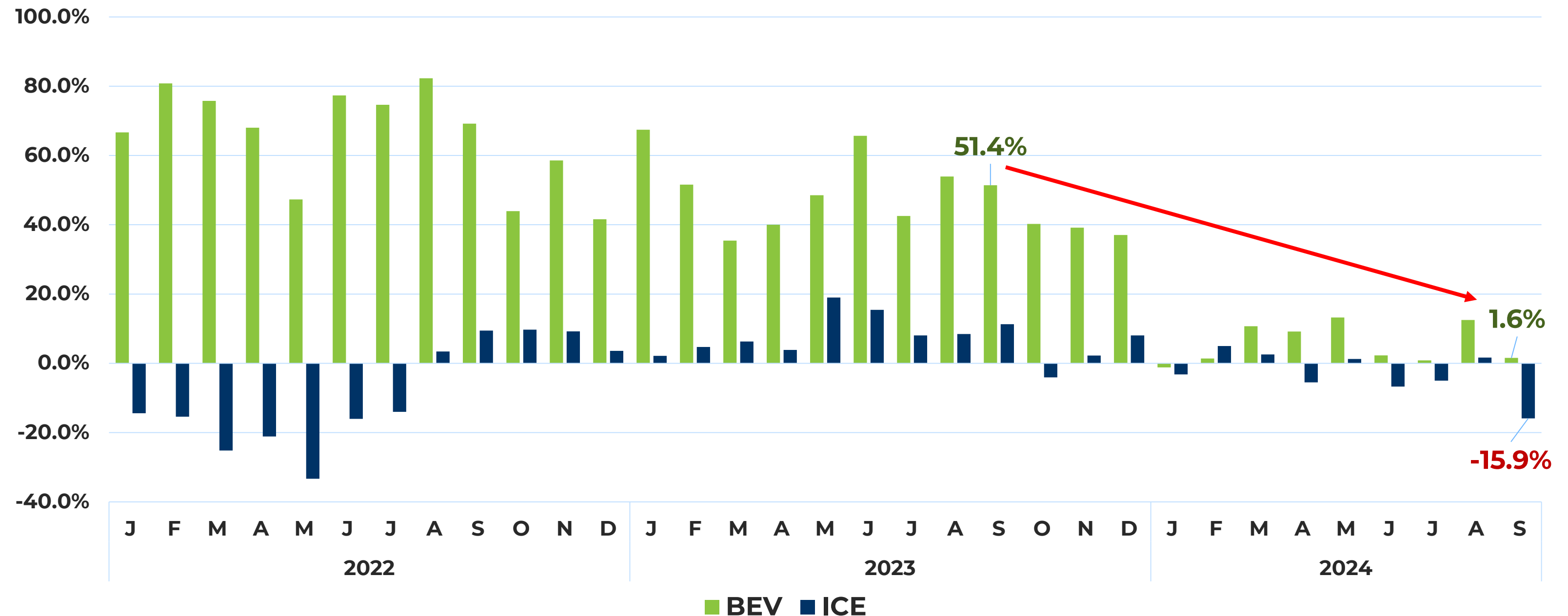




BEV sales slowing but still show growth – ICE sales in decline

U.S. BEV and ICE Sales

Year-on-year % change: 2022 – September 2024



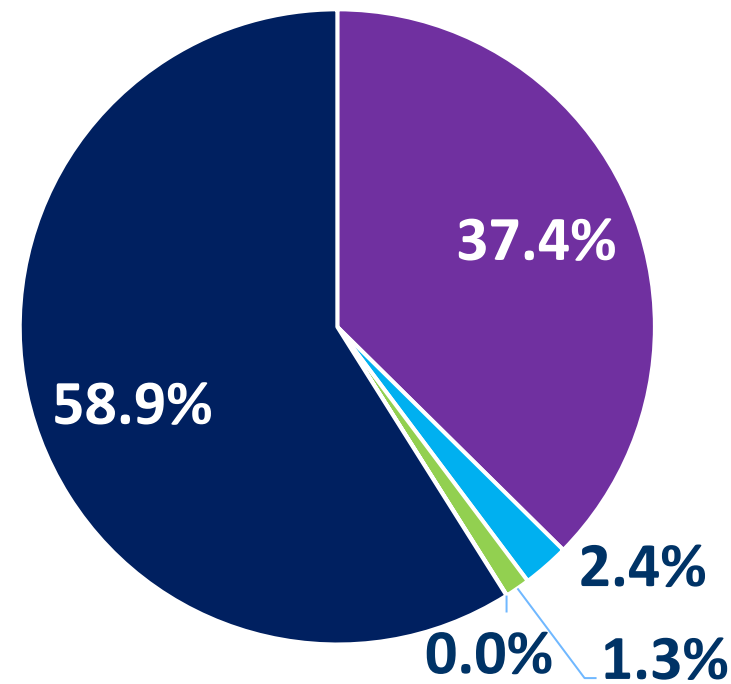
Source: Center for Automotive Research analysis of MarkLines data



Automaker EV Strategies: Toyota vs Detroit Three

US Sales by Powertrain Type, 2024 YTD (Q3)

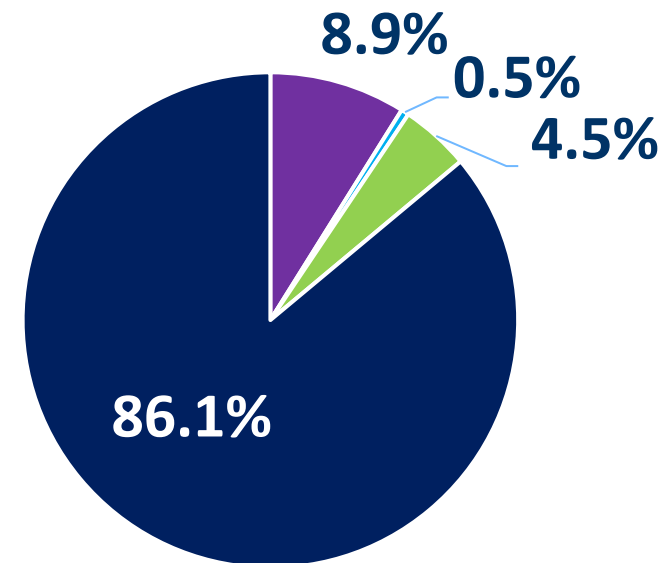
Toyota



41.1% Electrified

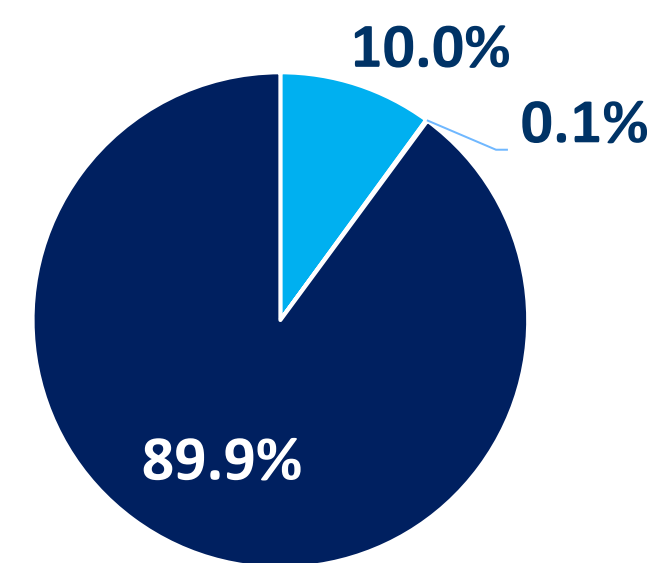
Detroit Three

Ford



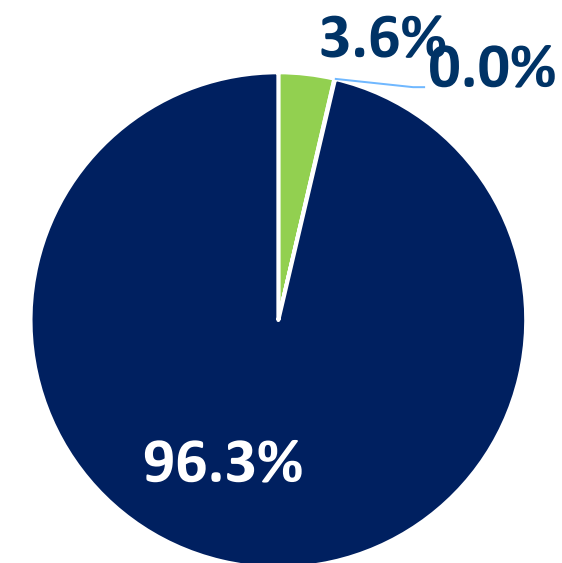
13.9% Electrified

Stellantis



10.1% Electrified

General Motors



3.6% Electrified

Electrified

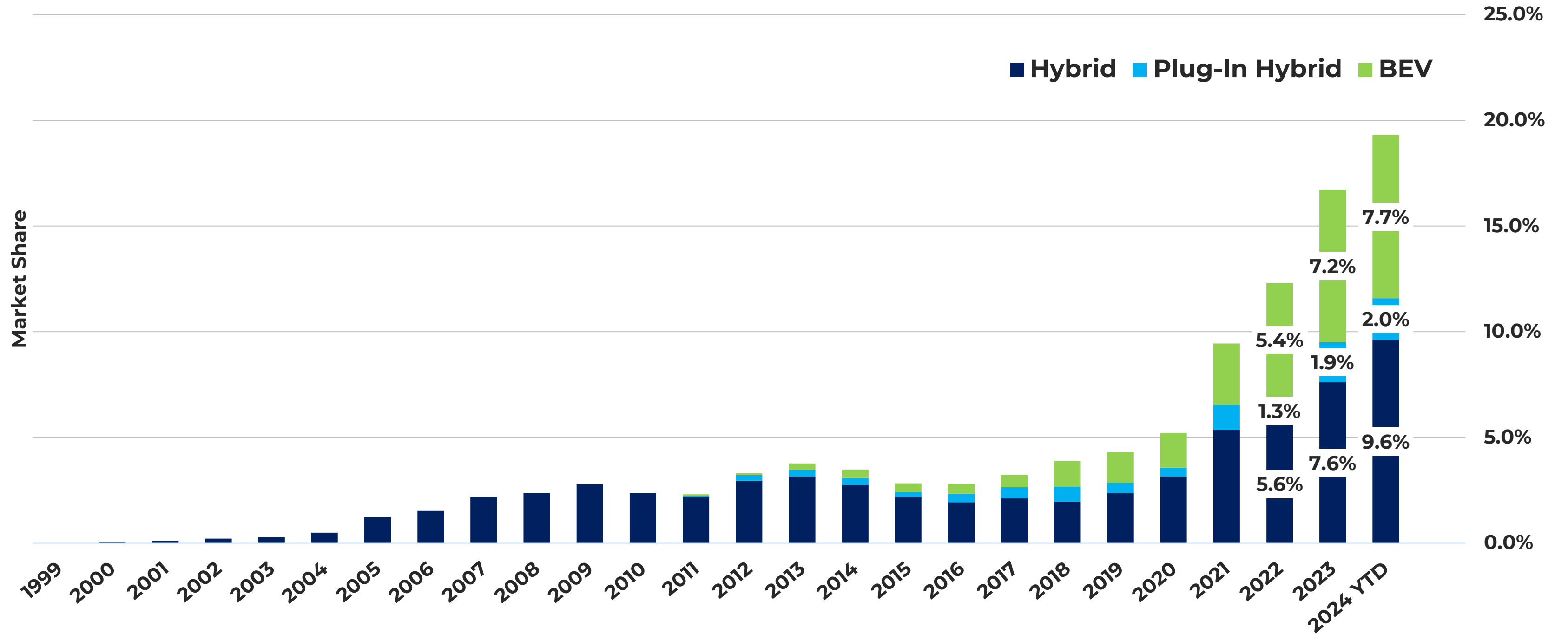
- ICE*
- HEV
- PHEV
- BEV
- FCEV

**Includes mild hybrids*



Battery Electric, Hybrids, and Plug-In Hybrids are at historically high market shares

U.S. Electrified Light Vehicle Sales by Propulsion Technologies
1999 – 2024 YTD (September)



Note: Electrified vehicles consist of BEV, HEV and PHEV

Source: Ward's Automotive Reports (from 2010 and on), HybridCars.com and CAR Research



Resurgence of Hybrids – Automakers Rethink EV Strategies

Automakers switch focus from BEVs to Hybrids

- GM reverses course and plans to bring back PHEVs to the US market after discontinuing in 2019
- Ford delayed BEV pickup and SUV production, plans to add hybrid models to their lineup
- Others, including Hyundai, Kia, and Aston Martin shift focus from BEV to Hybrids

Hybrid sales see rapid growth in 2024

- Hybrid sales are up 33% and PHEV sales are up 11% in the first three quarters of 2024 compared to the same period in 2023
- BEV sales through September are up 7%, compared to ICE sales which fell 3% over the same period.

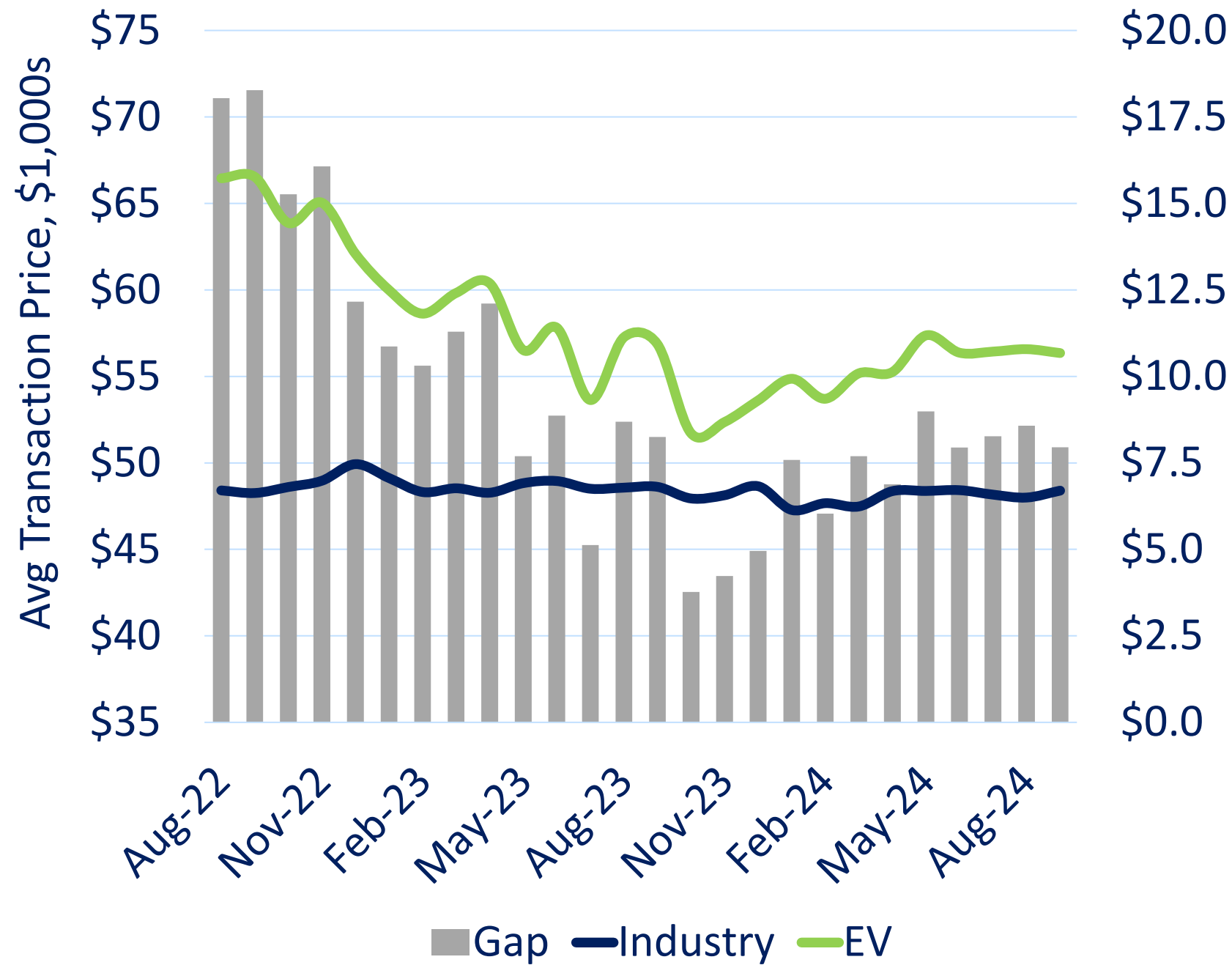
Focus on low-cost EV strategy



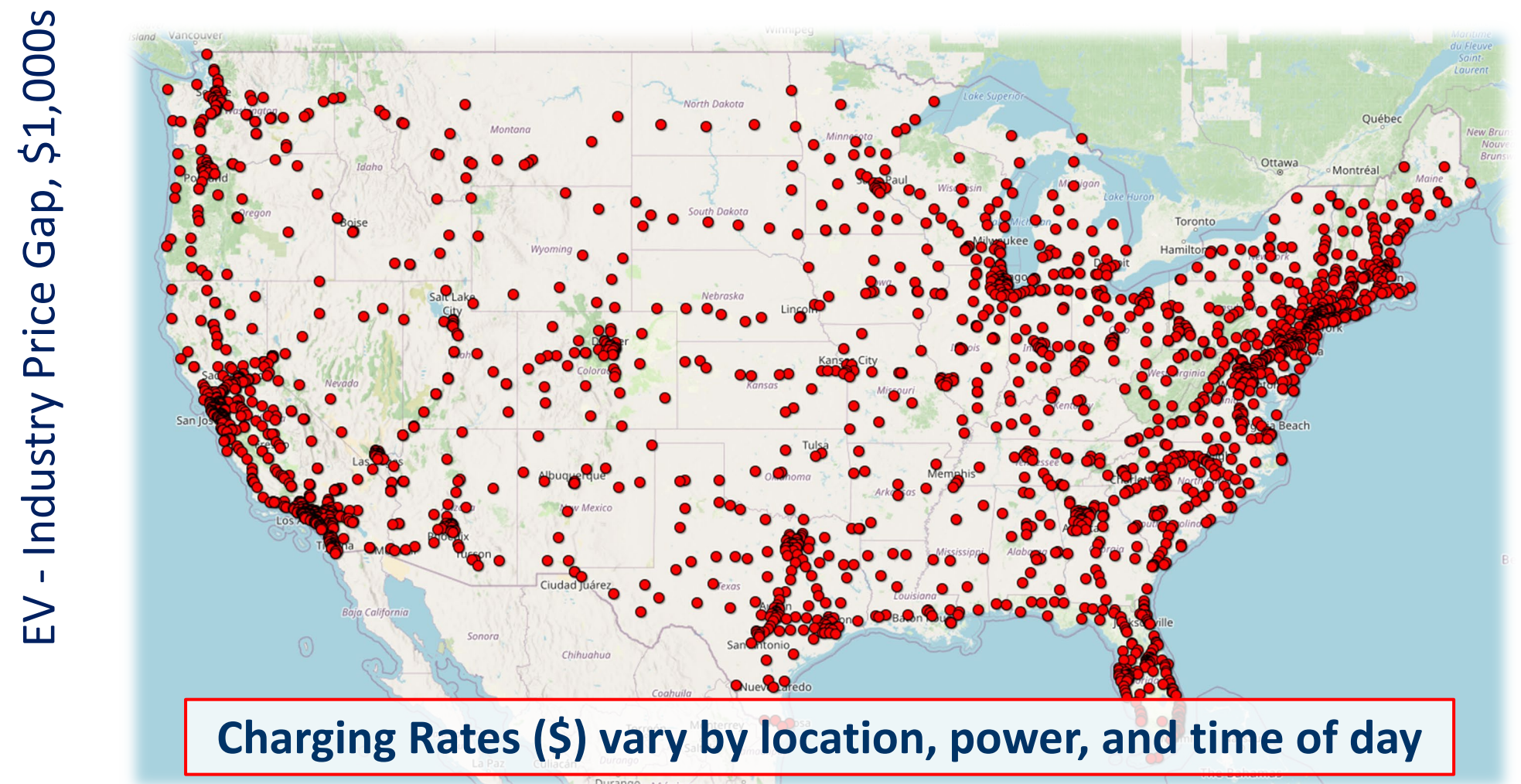
Drivers of EV adoption – Cost and Charging Access

United States

New Vehicle Transaction Price



Tesla Supercharger Network



“The opening of the Tesla network about **doubles the number of fast chargers** available to the general public”

- Automotive News (March 23, 2024)



EV Challenges

EVs 500-1000 kg heavier than ICE

- Tire composition and design
- Vehicle dynamics & chassis design
- Vehicle crash characteristics
- Lightweight materials

Battery repair, replacement, recycling

- Higher system voltage, breakdown voltages
- Higher temperatures, fire retardants
- Faster charging, alternative shielding solutions

- **EV charging infrastructure build-out**
 - Safe location- polymeric materials in housings
 - Maintained and operational, Accessible
 - Defacto standard on Tesla charging interface
 - \$5B federal program
- **Affordable & profitable?**
 - Giga press
 - Electric motors
 - Component integration
 - Toyota hybrid strategy, GM bringing back hybrids

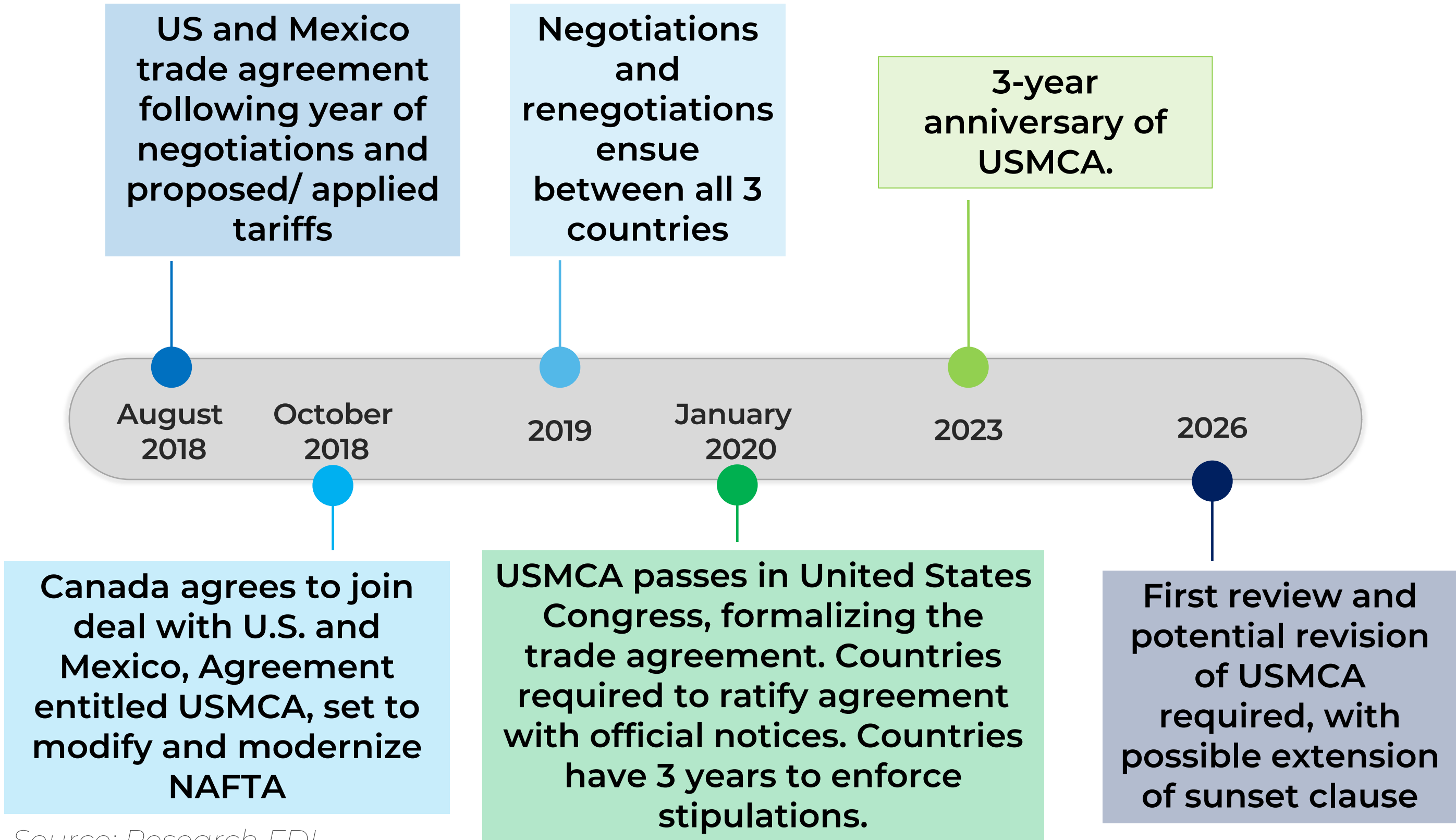


United States- Mexico-Canada Agreement (USMCA)





USMCA Timeline and Trade Implications



Implications for Automotive Industry:

- Cars and trucks with 75% of components manufactured in US, MX, CA can avoid tariffs (increased from 62.5% with NAFTA)
- At least 40-45% of manufacturing labor must be completed by workers earning minimum wage of \$16/hour

Rules of Origin

- Encourage more goods and materials to be manufactured in U.S.

Source: Research FDI

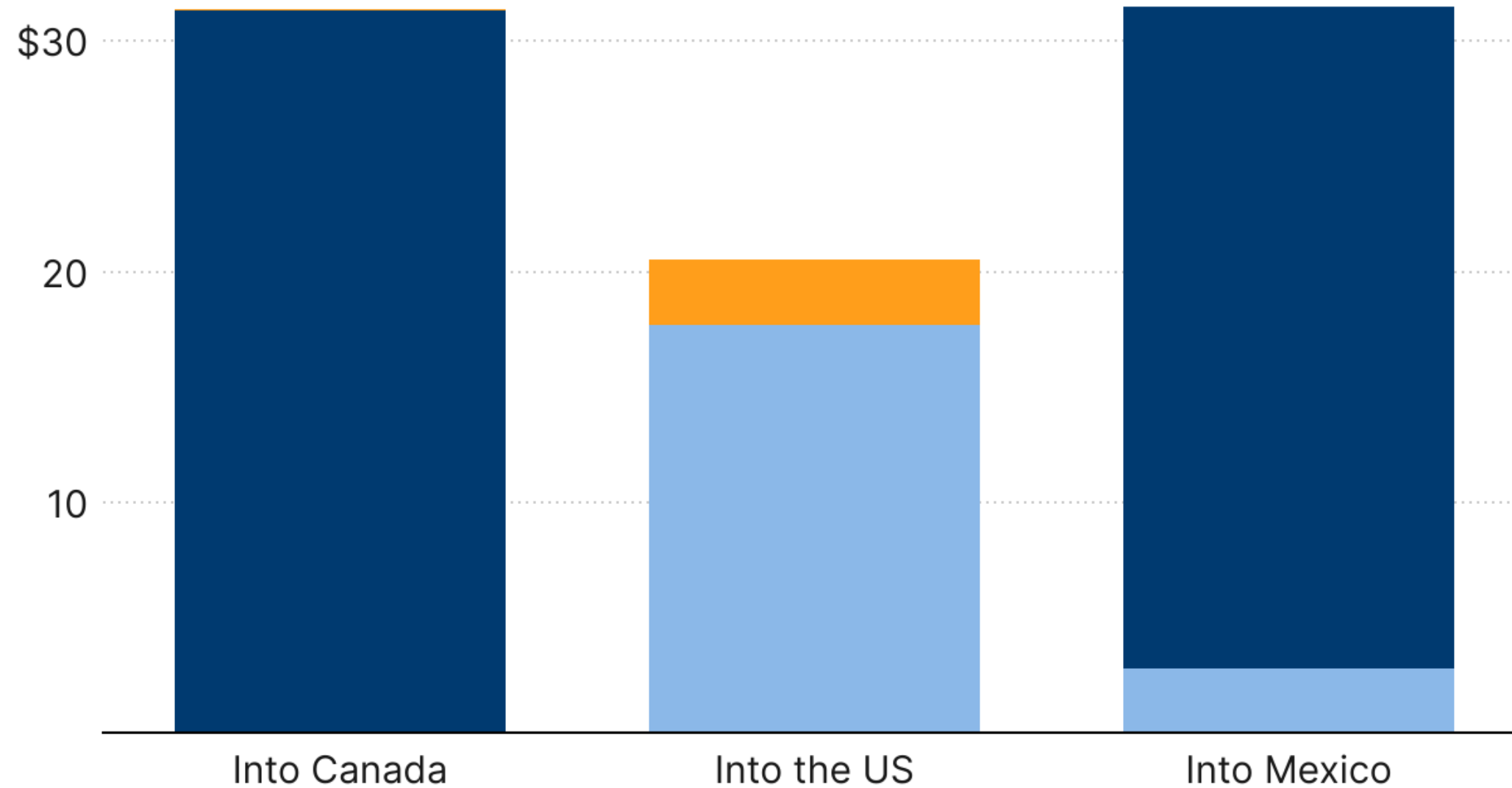


USMCA Intra-regional export growth

Foreign direct investment within North America since USMCA

Capital investment in billions of US dollars, July 2020-May 2023

From Canada From the US From Mexico



Joint Review of USMCA

- Review required 6 years following enactment, approved initially for a 16-year term (2036)
- Government review USMCA operation, assess recommendations submitted by governments, decide on action
- Considerations include 9 domains: compliance with dispute settlement outcomes, labor, digital trade, small and medium enterprises, regulatory alignment, workforce development, emergency planning, environment, transparency/outreach/coordination/metrics of success

Source: Brookings

SUMMARY

- **Unprecedented investment in EV across North America 2018 -2023**
- **IRA is a major driver of EV market growth**
- **BEV and PHEV sales forecasted to reach 54% in 2032**
- **OEMs looking for innovative solutions for reducing weight and cost**


First Name
Last Name

Yen
Chen

Tyler
Harp

THANK YOU

Center for Automotive Research

 +1(734) 662-1287

 info@cargroup.org

 www.cargroup.org

 880 Technology Dr. Suite C
Ann Arbor, MI 48108



CAR





MBS 2024

MANAGEMENT BRIEFING SEMINARS

SAVE THE DATE

AUGUST 5-8, 2024

TRAVERSE CITY,

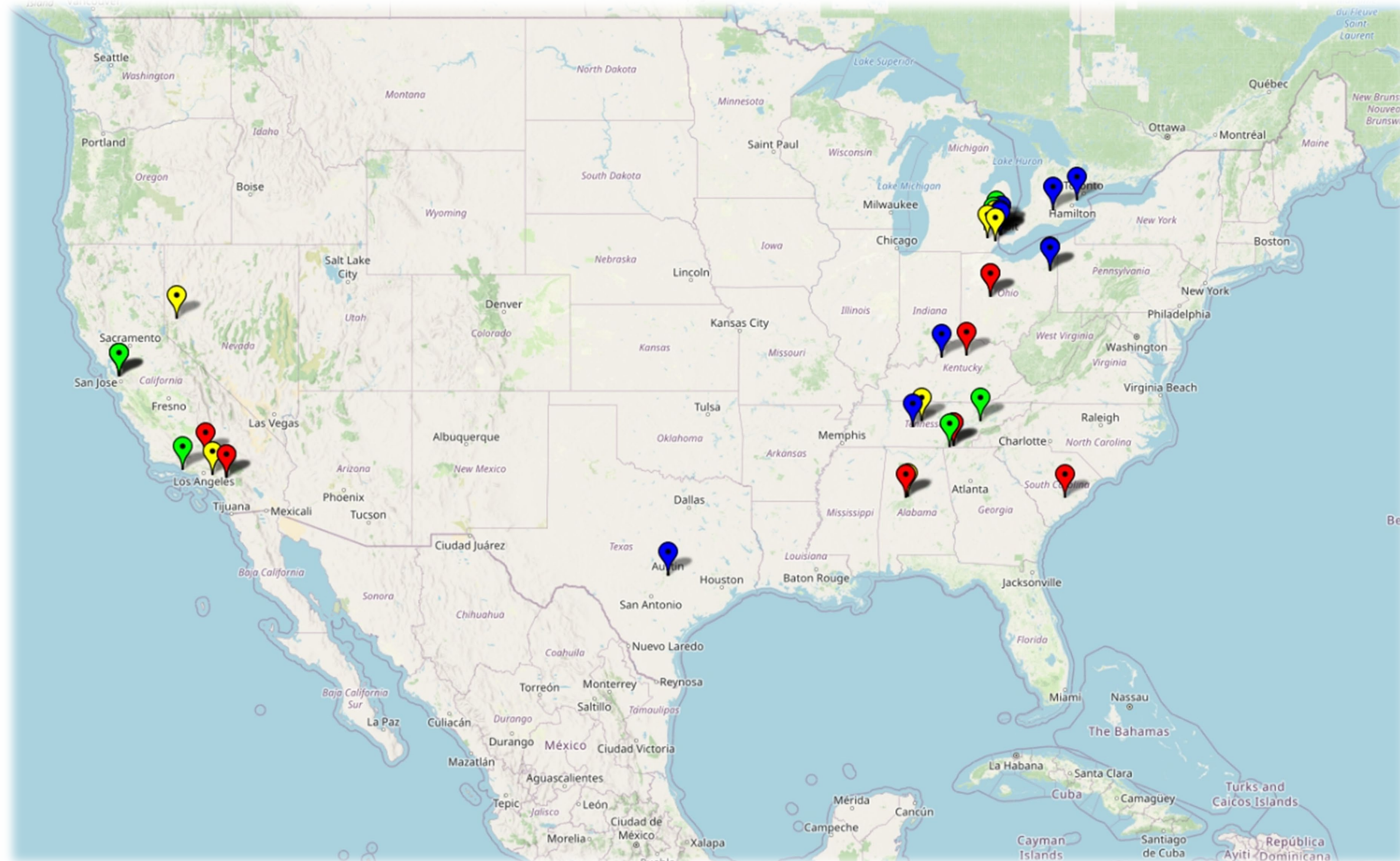
MICHIGAN









Major North America EV and Battery Investment Announcements by OEMs

2019 – 2020



Investment Type

-  Battery
-  Electric Vehicle
-  EV and Battery
-  R&D

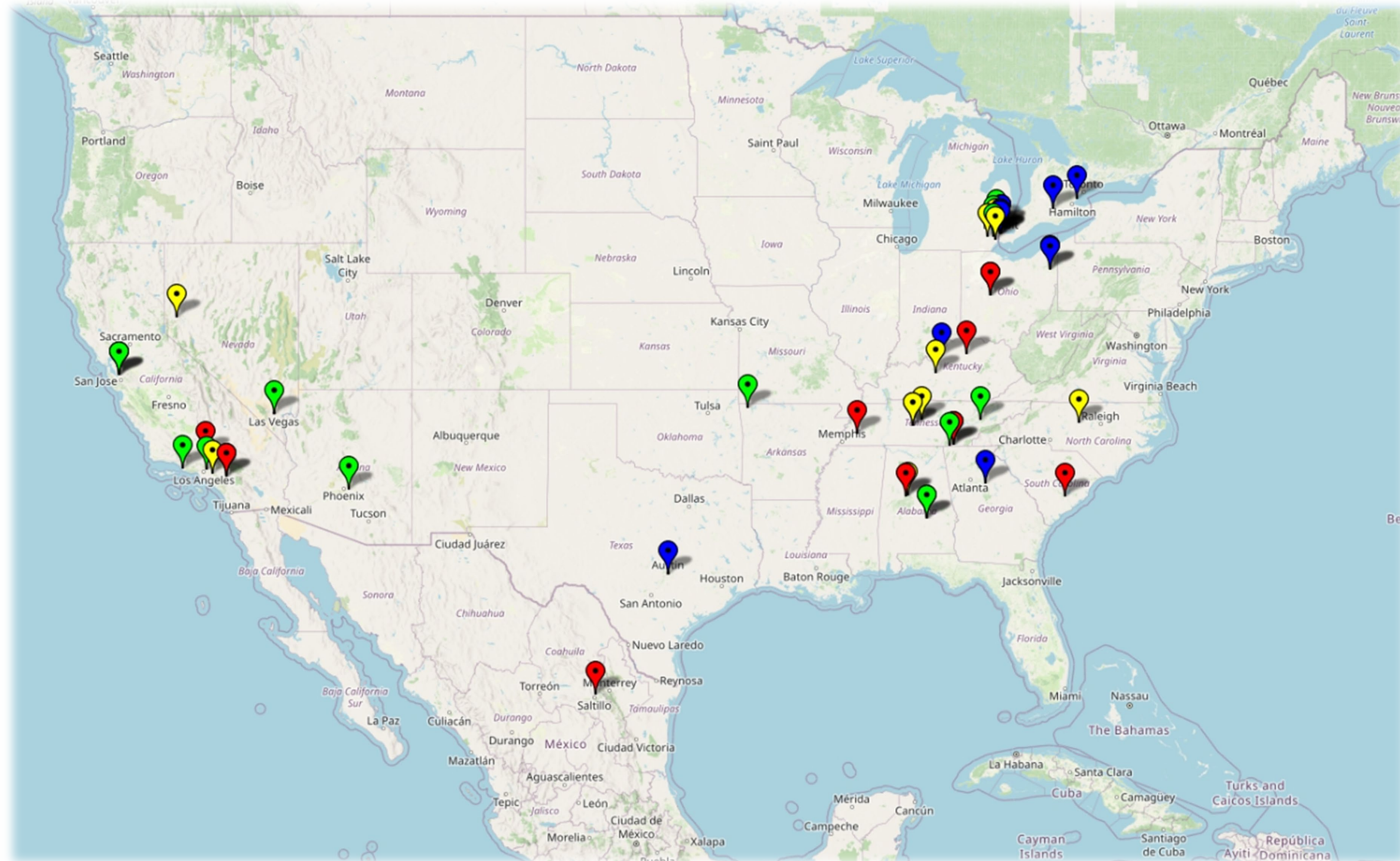
Source: CAR Book of Deals, GPS Visualizer

Note: Only Battery, Electric Vehicle, and EV and Battery announcements of over \$1.0 billion shown on map



Major North America EV and Battery Investment Announcements by OEMs

2019 – 2021



Investment Type

- Battery
- Electric Vehicle
- EV and Battery
- R&D

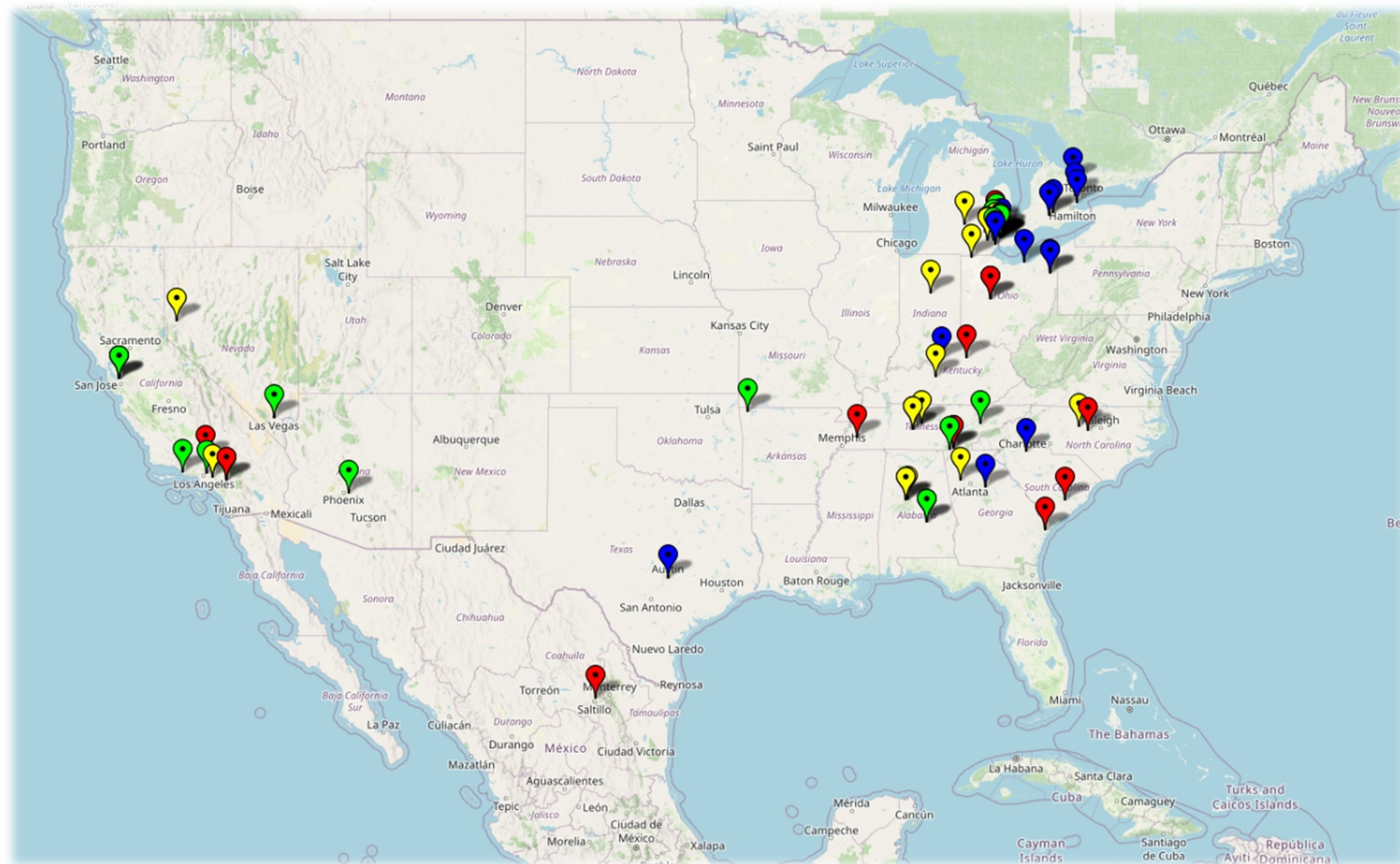
Source: CAR Book of Deals, GPS Visualizer

Note: Only Battery, Electric Vehicle, and EV and Battery announcements of over \$1.0 billion shown on map







Major North America EV and Battery Investment Announcements by OEMs

2019 – 2022



Investment Type

-  Battery
-  Electric Vehicle
-  EV and Battery
-  R&D

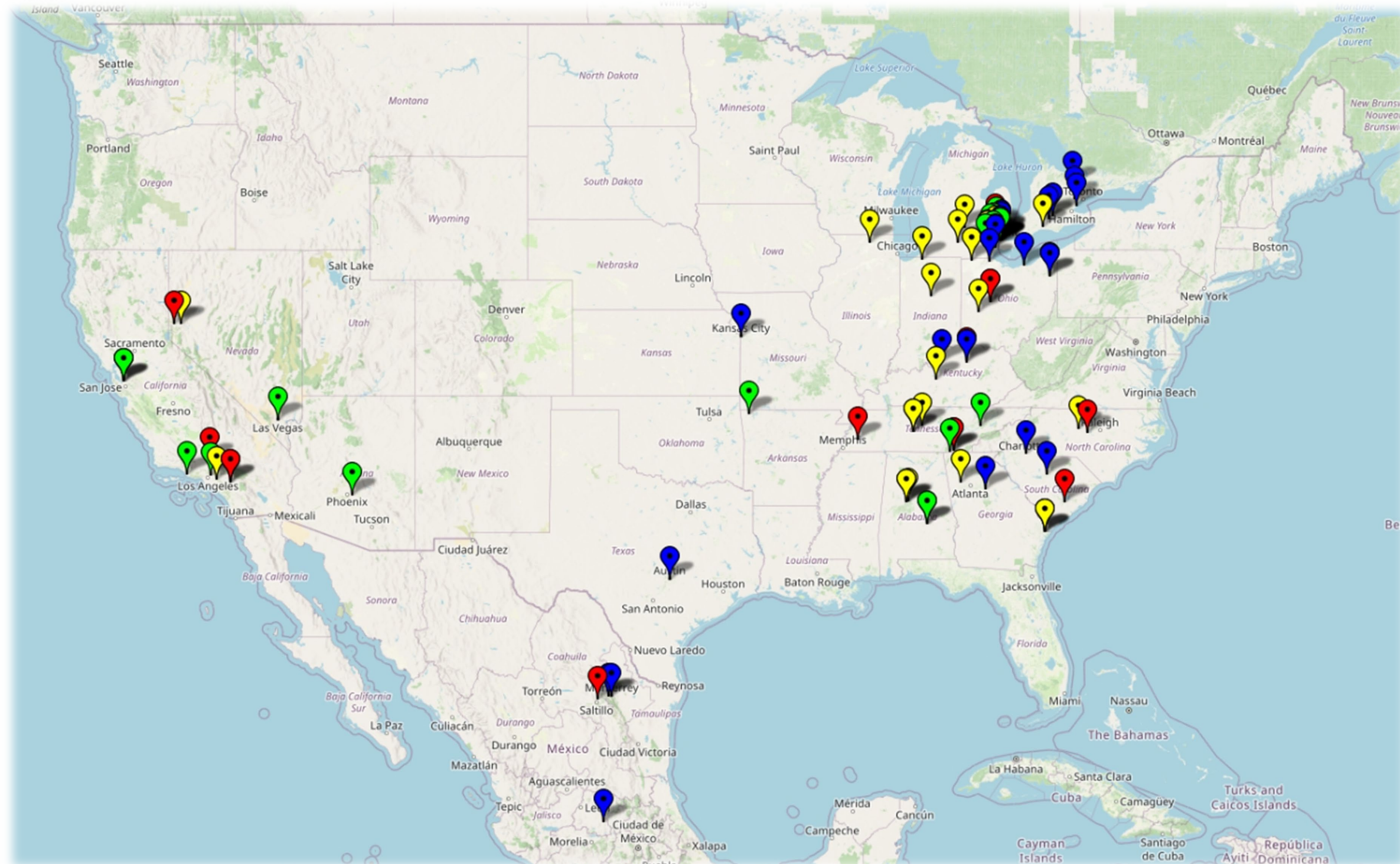
Source: CAR Book of Deals, GPS Visualizer

Note: Only Battery, Electric Vehicle, and EV and Battery announcements of over \$1.0 billion shown on map



Major North America EV and Battery Investment Announcements by OEMs

2019 – 2023



Investment Type

- Battery
- Electric Vehicle
- EV and Battery
- R&D

Source: CAR Book of Deals, GPS Visualizer

Note: Only Battery, Electric Vehicle, and EV and Battery announcements of over \$1.0 billion shown on map