CENTER FOR AUTOMOTIVE RESEARCH

# Electrification Transition Impacts

## on the Illinois Automotive Industry

November 2022

IMEC

ILLINOIS MANUFACTURERS' ASSOCIATION

# Presentation Outline

- Introduction to CAR
- Introduction to the Illinois Automotive Electrification Analysis
- Characterizing the Illinois Automotive Industry
- Automotive Electrification Trends and the Role Played by Illinois
- Illinois Automotive Supply Base Risk Assessment
- Conclusions and Recommendations
  - Top 5 opportunities
  - Top 5 concerns
  - Top 5 recommendations for Illinois stakeholders
- Appendix

# THE CENTER FOR AUTOMOTIVE RESEARCH (CAR)

Automotive industry contract research and service organization (non-profit ) with more than 30 years experience forecasting industry trends, advising on public policy, and sponsoring multi-stakeholder communication forums.

## RESEARCH

Independent research and analysis on critical issues facing the industry.

## EVENTS

Industry-driven events and conferences that deliver content, context, and connections.

## CONNECT

Consortia that bring together industry stakeholders to participate in working groups, networking opportunities, and access to CAR staff.

# Illinois Automotive Electrification Analysis

## Introduction

CAR would like to thank the Illinois Manufacturing Excellence Center (IMEC) for its support and guidance in the performance of this study

- The automotive industry is in the midst of its greatest transformation in over a century
- The transition to electric vehicles brings unprecedented opportunity for Illinois to benefit from an enormous wave of automotive investment, while bringing risk to producers of components not used on electric vehicles

This study

- Provides estimates of the scale and composition of the automotive industry in Illinois
- Describes the sweeping scale of automotive electrification transformation and the role played by Illinois automotive stakeholders
- Classifies Illinois automotive producers into high risk, low-to-moderate risk, and growth categories
- Makes recommendations intended to help Illinois maximize the benefit from automotive electrification while minimizing the risk it brings to traditional automotive component manufacturing

# Characterizing the Illinois Automotive Industry

# Economic Contribution to Illinois – Motor Vehicle Manufacturing

| Employment | Motor Vehicle Manufacturing-Related |
|---|---|
| Direct (Hourly + Salaried) | 11,500 |
| Intermediate | 25,821 |
| Total (Direct + Intermediate) | 37,321 |
| Multiplier | 4.5 |
| Total Earnings | $6.3 Billion |



*Source: CAR Analysis based on output from Regional Economic Modeling, Inc. (REMI) model*

# Economic Contribution to Illinois – Motor Vehicle Parts Manufacturing

| Employment | Motor Vehicle Manufacturing-Related |
|---|---|
| Direct (Hourly + Salaried) | 21,600 |
| Intermediate | 17,652 |
| Total (Direct + Intermediate) | 39,252 |
| Multiplier | 2.3 |
| Total Earnings | $4.9 Billion |



*Source: CAR Analysis based on output from Regional Economic Modeling, Inc. (REMI) model*

# 2021 Motor Vehicle and Parts Manufacturing Establishments – Top 10 States

| | 3361 MV Mfg. | 3362 MV Body & Trailer Mfg. | 3363 MV Parts Mfg. | Total |
|---|---|---|---|---|
| U.S. Total | 695 | 2,339 | 5,867 | 8,901 |
| Michigan | 86 | 91 | 811 | 988 |
| California | 86 | 203 | 552 | 841 |
| Ohio | 32 | 116 | 461 | 609 |
| Texas | 41 | 202 | 333 | 576 |
| Indiana | 28 | 175 | 335 | 538 |
| Tennessee | 40 | 66 | 288 | 394 |
| Illinois | 39 | 60 | 282 | 381 |
| Florida | 27 | 118 | 234 | 379 |
| Alabama | 36 | 58 | 211 | 305 |
| Kentucky | 18 | 49 | 212 | 279 |



*Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Census, Annual Survey of Manufactures*

# 2021 Motor Vehicle and Parts Manufacturing Employment – Top 10 States

| | 3361 MV Mfg. | 3362 MV Body & Trailer Mfg. | 3363 MV Parts Mfg. | Total |
|---|---|---|---|---|
| U.S. Total | 253,558 | 163,345 | 538,967 | 955,870 |
| Michigan | 45,057 | 8,038 | 121,783 | 174,878 |
| Indiana | 20,258 | 47,965 | 58,739 | 126,962 |
| Ohio | 21,591 | 8,994 | 66,683 | 97,268 |
| Tennessee | 17,572 | 2,574 | 41,606 | 61,752 |
| Kentucky | 22,043 | 3,866 | 31,738 | 57,647 |
| Alabama | 16,635 | 4,452 | 24,189 | 45,276 |
| Texas | 13,326 | 9,321 | 20,029 | 42,676 |
| California | 24,871 | 6,702 | 10,850 | 42,423 |
| South Carolina | 12,783 | 3,017 | 20,932 | 36,732 |
| Illinois | 10,383 | 3,256 | 21,151 | 34,790 |

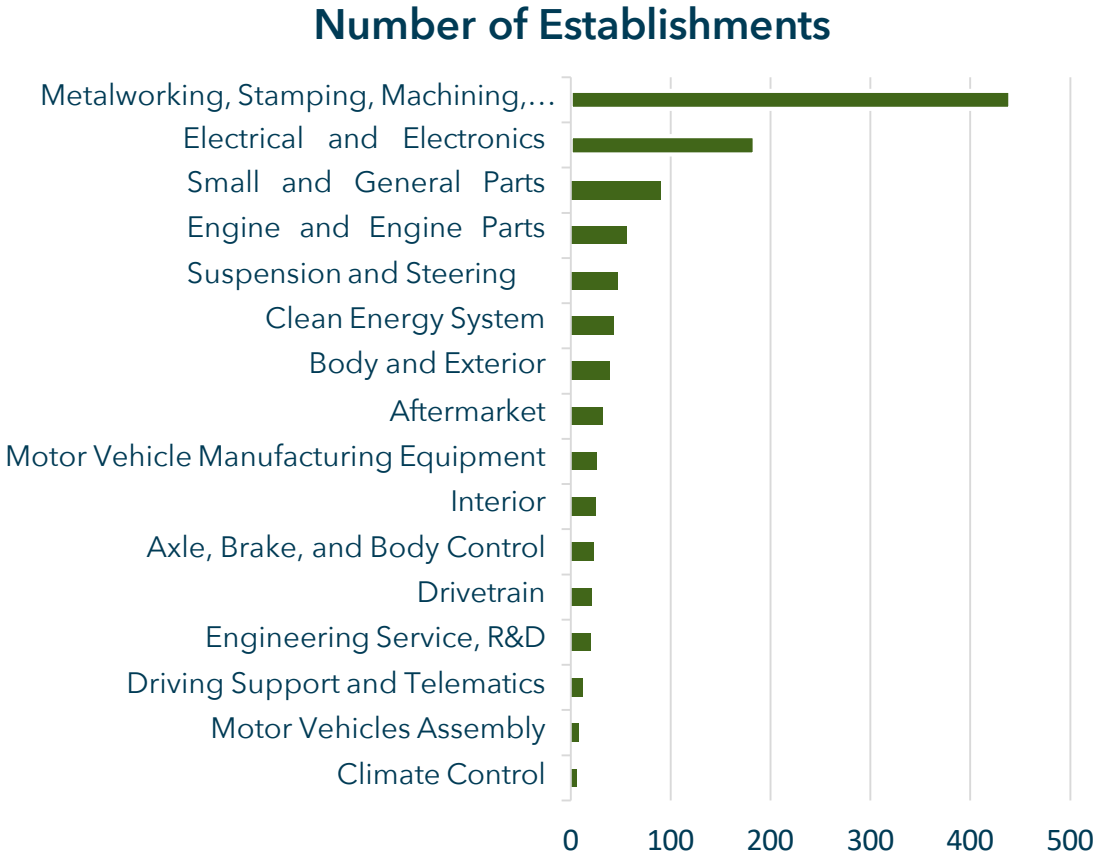


*Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Census, Annual Survey of Manufactures*

# Individual Company Analysis Summary

## Illinois Automotive and Related Industries

| | Number of Establishments | Sum of Employees |
|---|---|---|
| Aftermarket | 32 | 1,044 |
| Axle, Brake, and Body Control | 23 | 2,417 |
| Body and Exterior | 39 | 8,360 |
| Clean Energy System | 43 | 7,590 |
| Climate Control | 6 | 546 |
| Drivetrain | 21 | 2,019 |
| Driving Support and Telematics | 12 | 1,302 |
| Electrical and electronics | 184 | 10,566 |
| Engine and Engine Parts | 56 | 6382 |
| Engineering Service | 19 | 821 |
| Interior | 25 | 2,398 |
| Metalworking, Stamping, Machining, Molding | 440 | 18,564 |
| Motor Vehicle Manufacturing Equipment | 26 | 1,265 |
| Motor Vehicles Assembly | 8 | 13,094 |
| Research and Development (R&D) | 1 | 10 |
| Small and General Parts | 91 | 5,185 |
| Suspension and Steering | 47 | 7,496 |
| ***Grand Total*** | ***1,073*** | ***89,059*** |

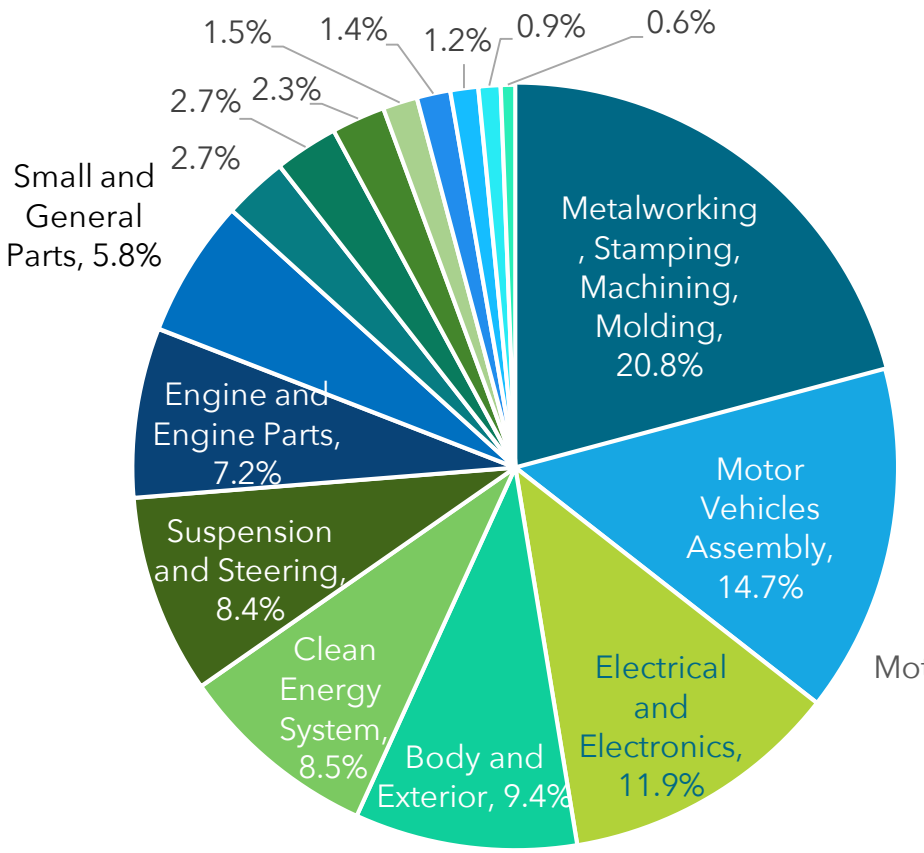


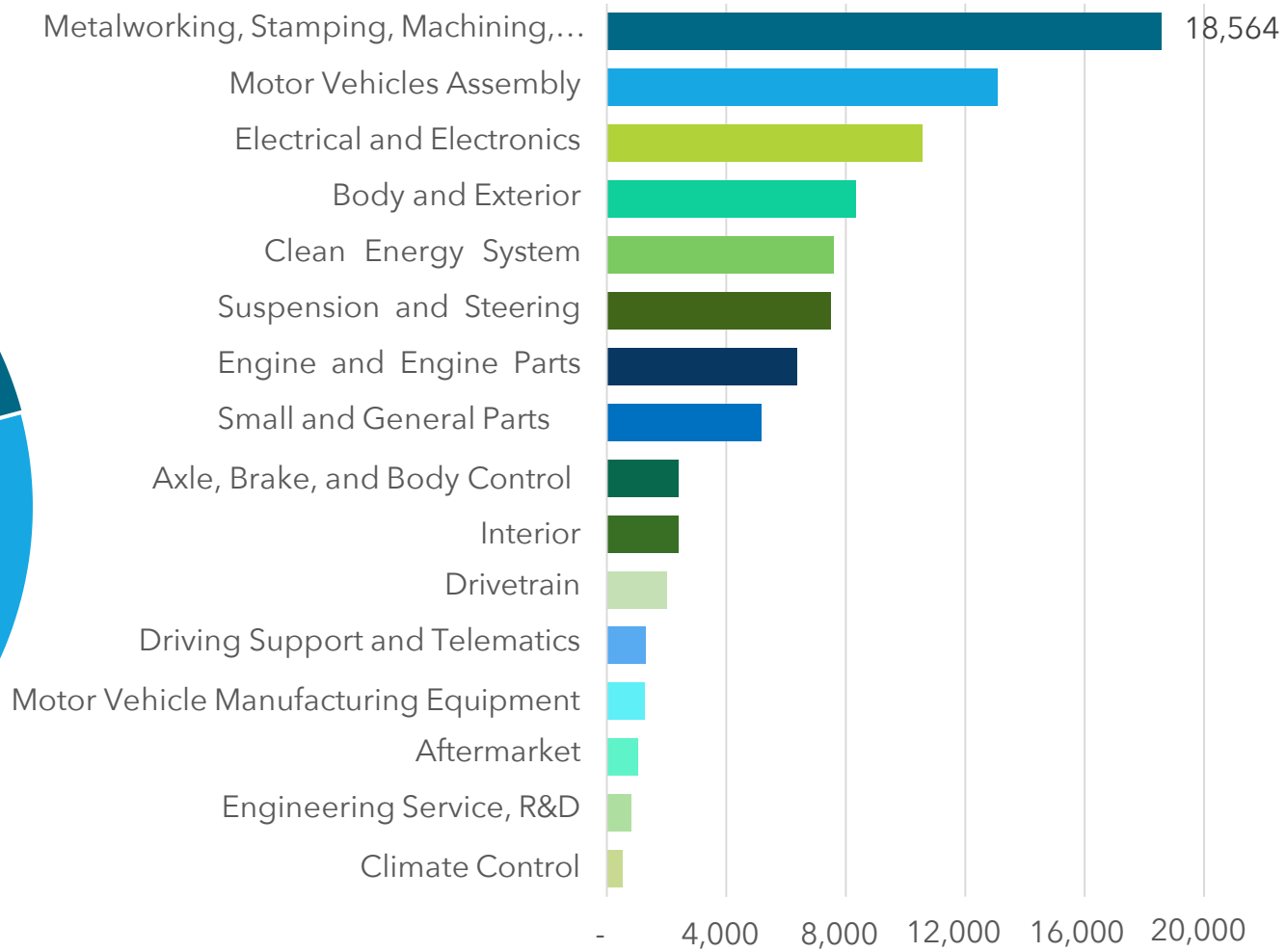



*Source: CAR Analysis based on the data from IMAPC, MNI, and Marklines*

# Illinois Automotive and Related Industries

## Employment

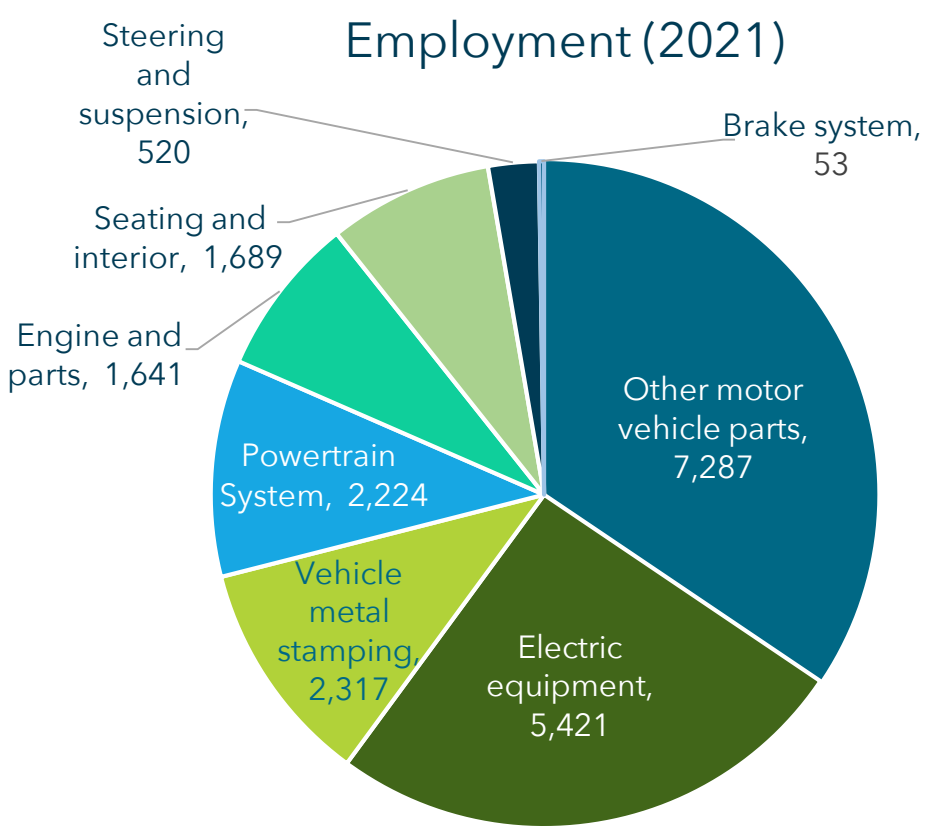


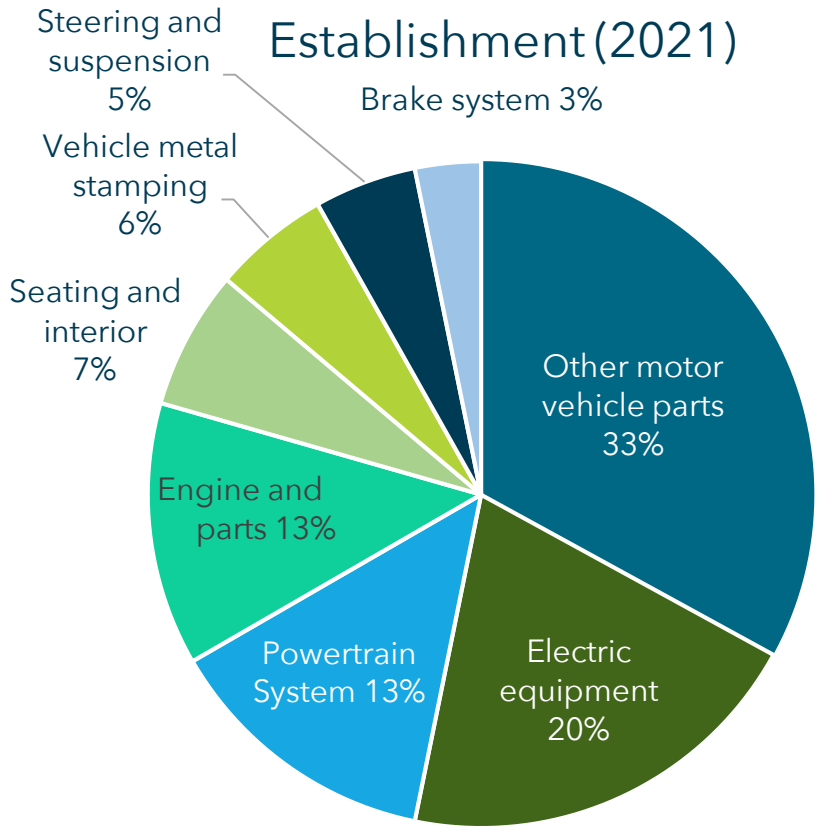






*Source: CAR Analysis based on the data from IMAPC, MNI, and Marklines*

# Motor Vehicle Parts Manufacturing in Illinois






*Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages*

# Illinois Automotive Industry Analysis – Part 1

- Illinois' manufacturing establishments and employment skew toward metalworking, machining, stamping, and molding industries
- They account for 41% of total establishments and 21% of employment in the database
- They also tend to be small by employment size. The average employees per establishment are 42, one of the smallest industry in the industry category; only aftermarket establishments are smaller
- Motor vehicle manufacturing establishments on average are the largest employers in the database. They accounted for only 1% of total establishments, but employed 15% of workers. The average number of workers per establishment is 1,632.
- Motor vehicle manufacturing equipment establishments are much smaller and are located near assembly plants in Illinois, Missouri, and Indiana.
- Electrical and electronic manufacturing establishments are the third largest industries in the database, accounting for 17% of total establishments and 12% of total employment. They are mostly located in Cook, DuPage, and Lake counties.

# Illinois Automotive Industry Analysis – Part 2

- Body and exterior establishments account for 4% of total establishments, and 9% of employment. They do not necessarily locate at or near assembly plants because their products can be shipped economically.
- Interior parts establishments account for only 2% of total establishments and 3% of employment. Their products are usually bulky and fragile, and sometimes need to be produced in sequence. Their locations are usually at or around assembly plants.
- Clean energy systems and driving support system establishments are mostly located in the Greater Chicago area. A few are near Rivian's assembly plant in Normal, IL. Clean energy systems account for 4% of total establishments and 9% of total employment.

# Illinois Automotive Industry Analysis – Part 3

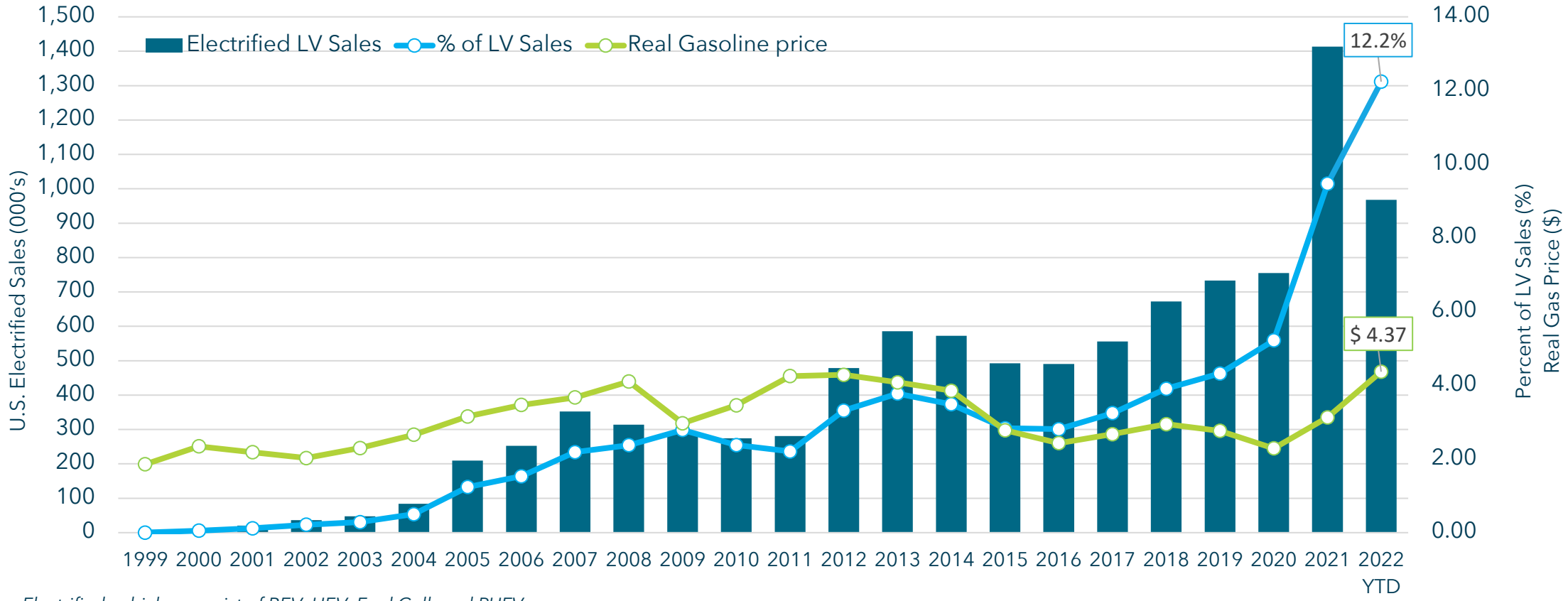
- Axle, brake, body control, steering, suspension, wheel, and tire establishments are located in the Greater Chicago and across the state of Illinois. Axle/brake/body control account for 3% of employment; Steering/suspension/wheel/tire account for 8% of employment.
- Engine and drivetrain account for 7% and 2% of employment, respectively. These two categories are the most vulnerable industries in the vehicle electrification transition. A total of 8,401 workers are employed by a total of 77 establishments in engine and drivetrain categories.
- Small and general parts manufacturing establishments do not have clear clusters except for in the Greater Chicago area. They account for 8% of total establishments and 6% of total employment.

# Automotive Electrification Trends and the Role Played by Illinois

# U.S. electrified vehicle sales have experienced dramatic growth decoupled from the real price of gasoline

## U.S. Electrified Light Vehicle Sales & Market Share

*1999 – 2022 July YTD*




*Note: Electrified vehicles consist of BEV, HEV, Fuel Cell, and PHEV*

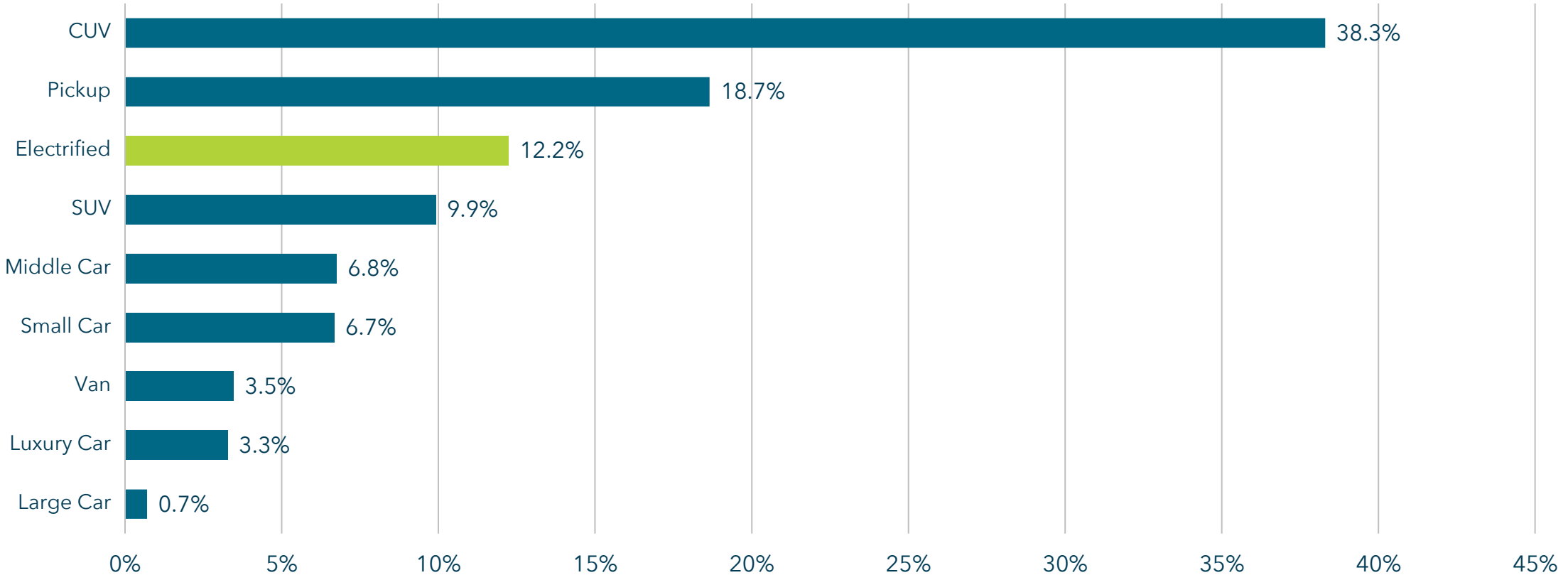


*Source: Wards Automotive Reports (from 2010 and on), HybridCars.com and CAR Research*

# Electrified vehicles have become the third largest vehicle segment in the United States

## Market Share: Segment Breakdown

*U.S. Light Vehicle Sales 2022 YTD Through July*




*Note: Electrified Segment consists of BEVs, HEVs and PHEVs; all other segments are sales exclusive of Hybrid models*

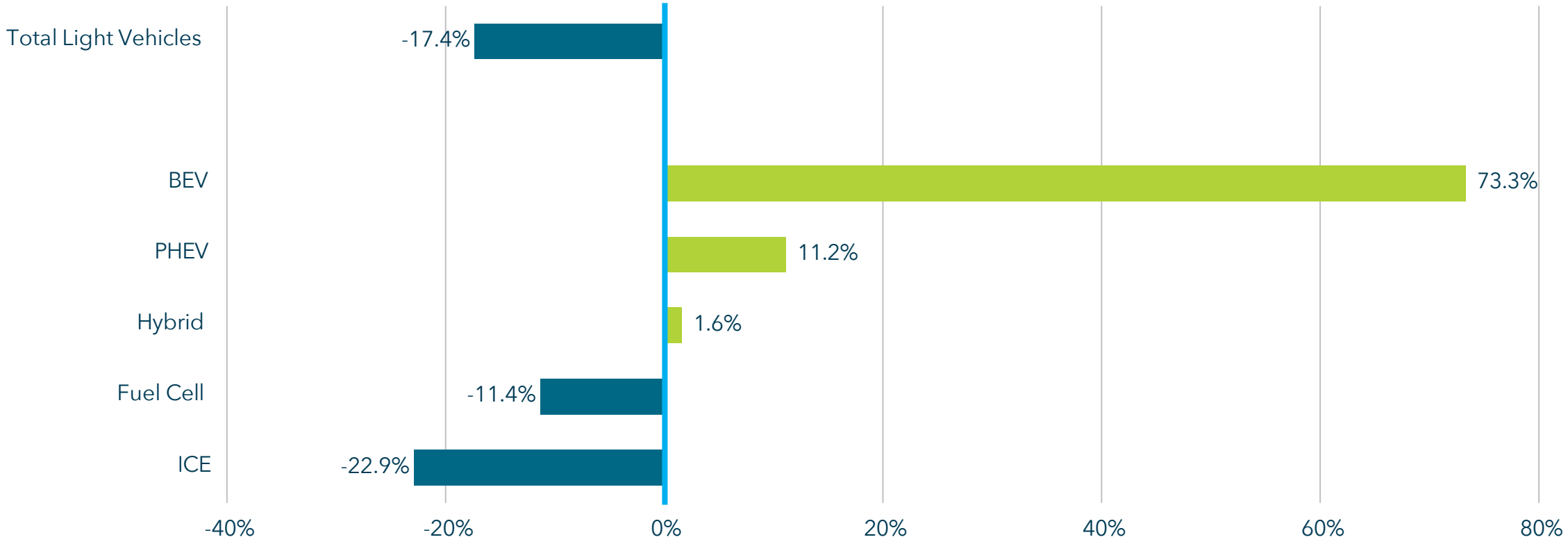


*Source: Wards Automotive Reports and CAR Research*

# Electrified vehicles see a massive increase in year-to-date sales while sales of Internal Combustion Engine (ICE) vehicles are down nearly 23%

## Segment Breakdown: U.S. Light Vehicles Sales Percent Change

*2022 YTD vs. 2021 YTD Through July*




*Note: All other segments are sales exclusive of Hybrid models*



*Source: Wards Automotive Reports and CAR Research*

# Automakers continue to announce sweeping plans for electrification

**2021**

***Tesla***
936k EVs delivered
***Ford***
Mache E sells over 27,000
***Audi***
80,000 EV sold
***GM***
Chevy sold over 20,000 EVs
***Mercedes***
99,000 EVs sold
***Jaguar***
i-Pace sold 9,970
***Rivian***
Delivered and sold around 1,000 EVs
***Kia***
Over 8,000 EVs sold
***VW***
263K BEVs delivered
***Volvo***
25K BEVs sold

**2022**

***GM***
Six-fold increase in EV truck and SUV production
***Ford***
Projecting at least a 25% growth in EV revenue and several new models
***Tesla***
Projecting over 1.4M EVs delivered

**2023**

***GM***
400,000 EVs delivered
***Ford***
600,000 EVs produced
***Kia***
Two EV models will be released
***VW***
Ability to produce 1M EVs/year in China
***Stellantis***
First Jeep EV released

**2024**

***Rivian***
Production begins in their Georgia plant
***Audi***
Starts production in Chinese that aims to produce 150,000 EVs/year

**2025**

***Genesis***
EVs will be the only new models
***Ford***
Have sold a total of 1M EVs
Begins battery production in Kentucky plant
***GM***
30 models by this time
***Kia***
20% of sales in Euro, NA, and Korea will be EVs
***Audi***
20 models by this time
***VW***
ID.2 production will begin
***Ram***
*Ram 1500 EV released*
***Mercedes***
50% of sales to be EVs
***Nissan***
EV plant will begin assembly in Mississippi

**2027**

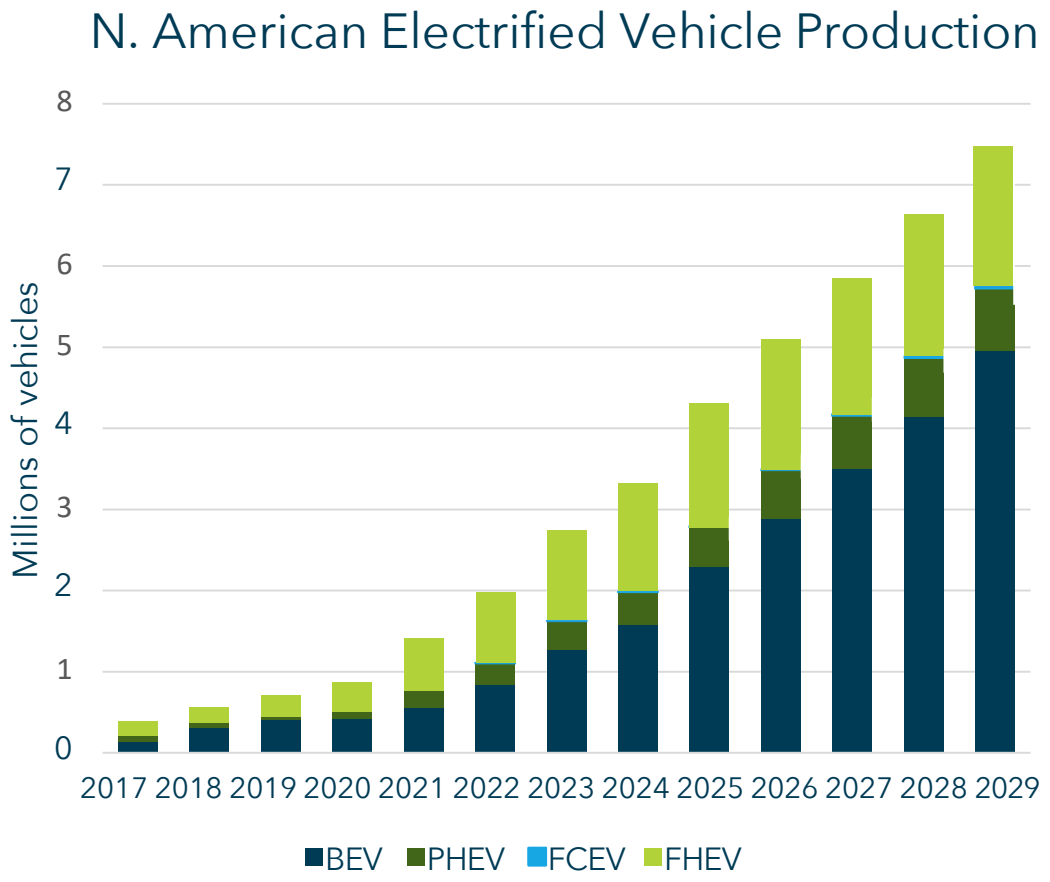
***Kia***
*14 EV models by this time*

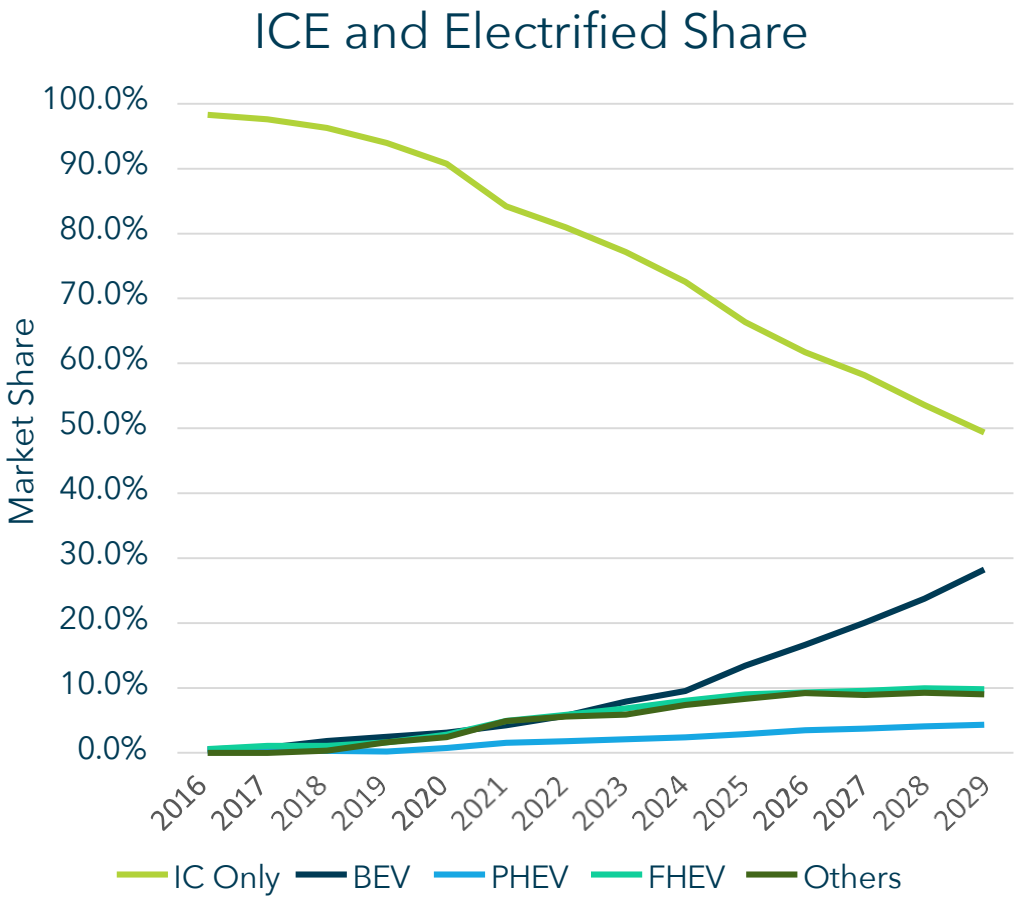
**2030**

***Ford***
40%-50% of global vehicle volume to be electric
***Subaru***
40% of global sales will be EVs or HEVs
***GM***
50% of NA assembly capacity will be converted to EV production
***GM***
70% of Euro sales will be EVs
***Hyundai***
Sell 1.87M EV/year 11 New models
***Kia***
Sell 1.2M EV/year
***Volvo***
Fully Electric
***Toyota***
Sell 3.5M EVs/year
***Stellantis***
50% of US sales BEV
100 % of Euro sales BEV
25 models by this time
***Nissan***
40% of sales to be EVs
***Genesis***
Internal combustion vehicles phased out

*Source: CAR Research*

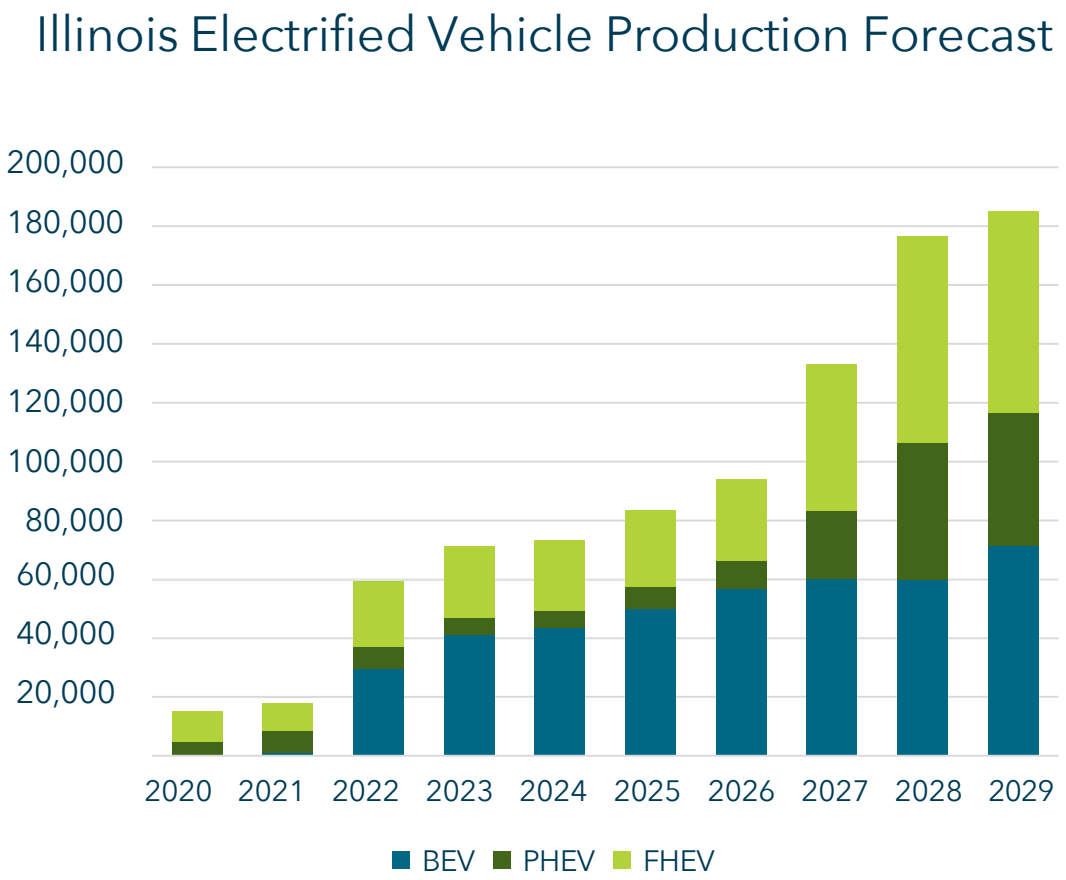
# Electrified Vehicle Production to Grow Rapidly

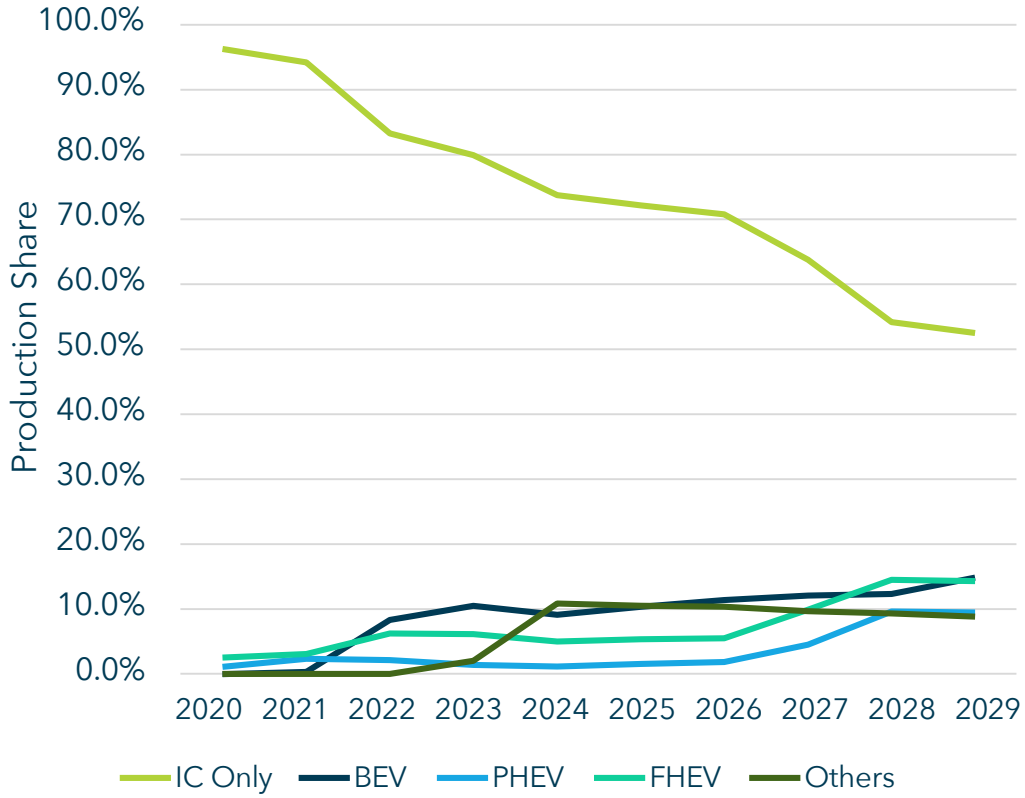



*Source: LMC Automotive*

# Illinois' Electrified Vehicle Production Forecast

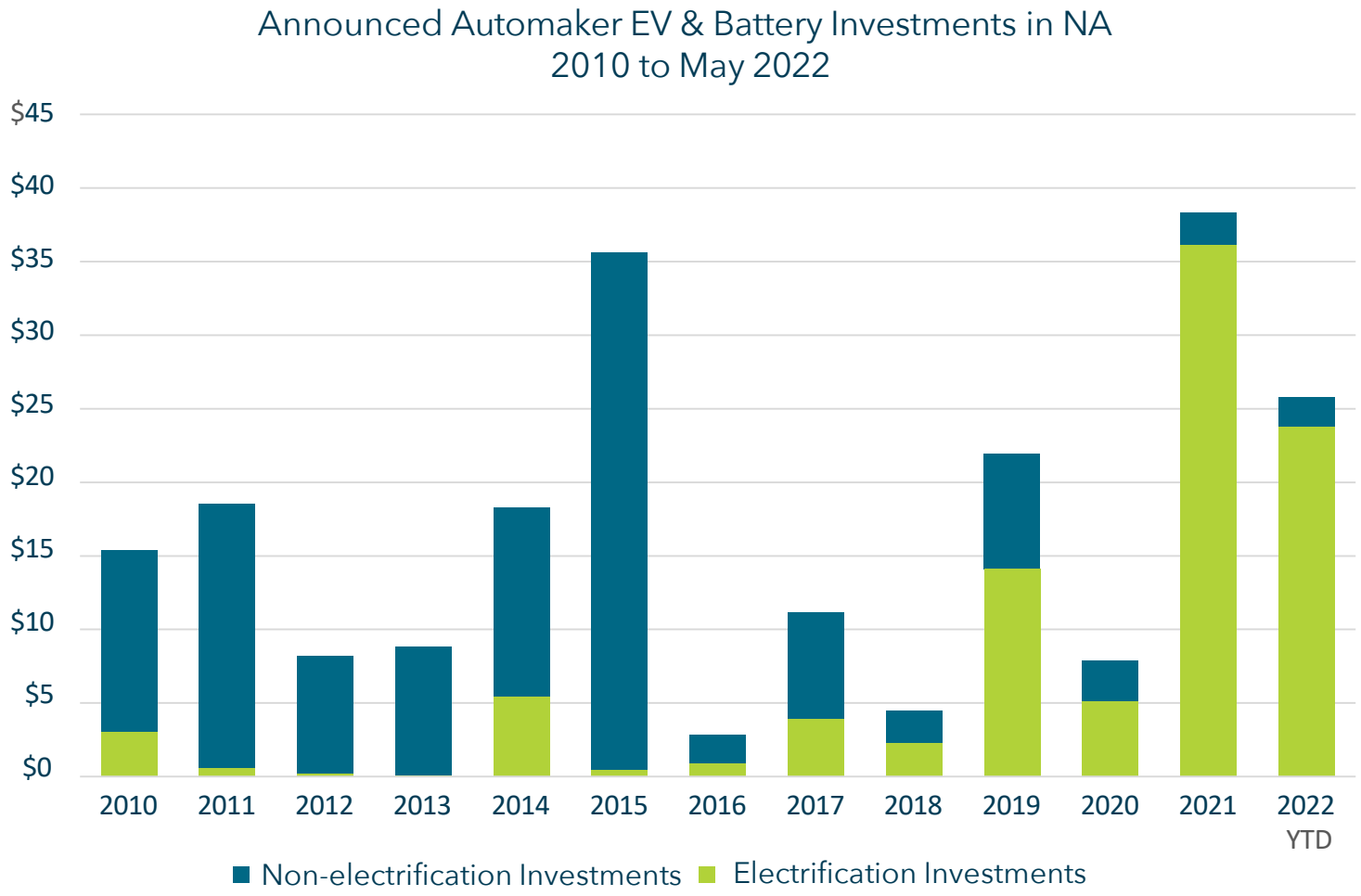



*Source: LMC Automotive*

# Announced Automaker EV & Battery Investments in NA

## Top 5 Automakers with YTD 2022 Investment Announcements

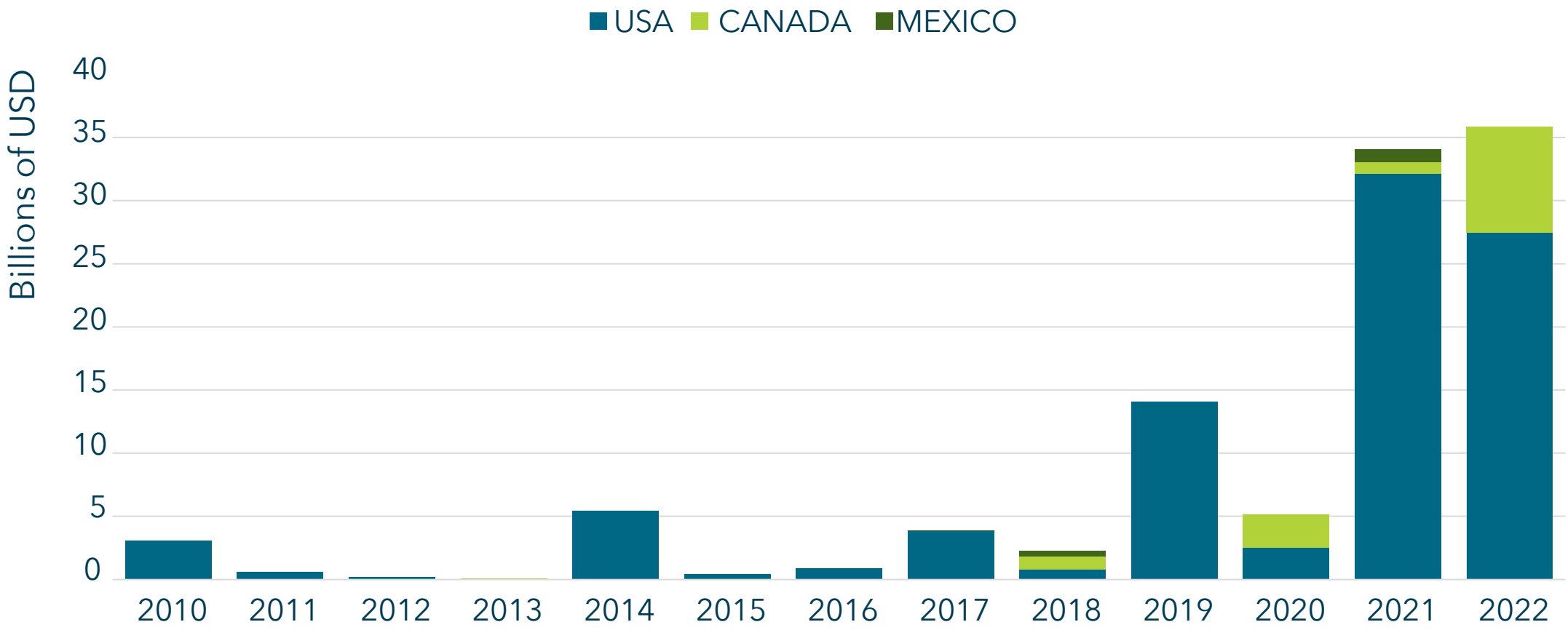



| Top 5 Automakers in 2022 | Total Investment Amount ($USD) |
|---|---|
| GM | $9.2B |
| Stellantis | $6.6B |
| Hyundai | $5.8B |
| Rivian | $5B |
| Honda | $1.4B |

*Source: 23AR Book of Deals, 2022*

# Automaker Announced Electrification Investment

## 2012 – 2022

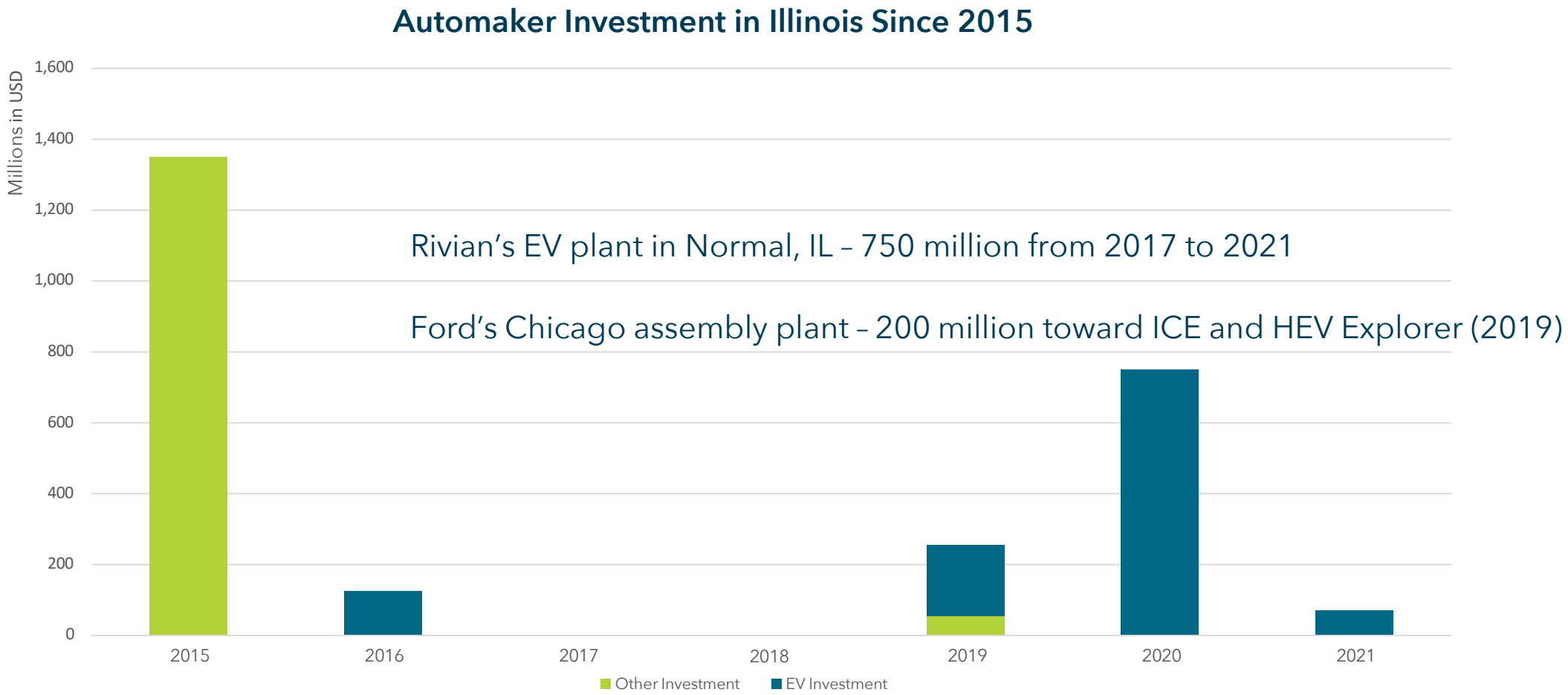



*Note: Announcements in 2019 reflect UAW contracts*

*Source: Center for Automotive Research, Book of Deals*

# Automaker Investment in the State of Illinois

## 2015 – 2022




*Note: Investment data based on publicly available announcements, in some cases the actual amount of investment is unknown*

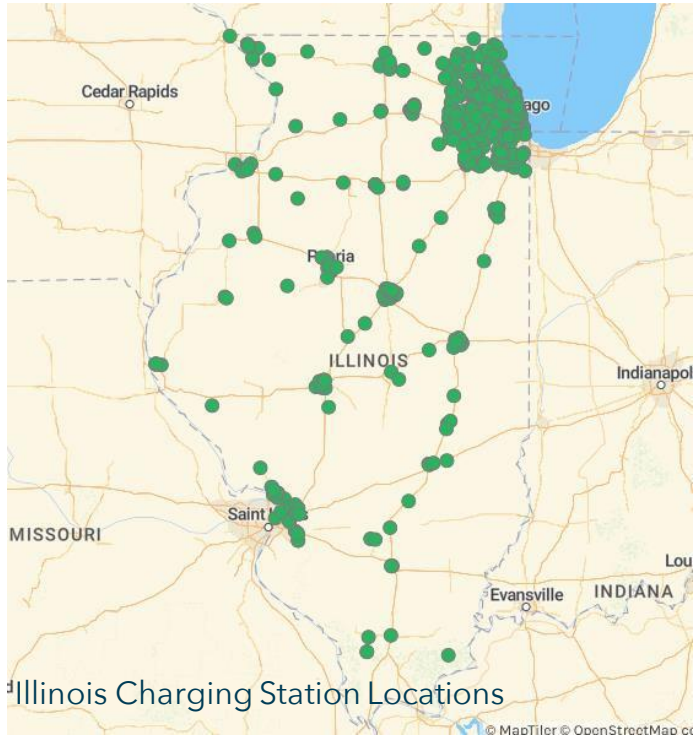


*Source: Center for Automotive Research, Book of Deals*

# Opportunities in Building the U.S. EV Charging Network

- The United States must invest heavily in an expanded vehicle charging network.
- President Biden has pledged to increase the number of public charging from the roughly 46,000 available in 2021 to 500,000 by 2030 (U.S. Department of Energy, Alternative Fuels Data Center, 2022).
- The Infrastructure, Investment, and Jobs Act contains USD 5 billion to help build the public EV charging network (U.S. Congress, 2021).
- To reach the President's goal of BEVs and PHEVs making up 50 percent of new light vehicle sales by 2030, the nation will need at least 1 million public chargers.

| State | Registered EVs | Total Vehicle Registrations | % of Vehicles That Are EVs | Public Charger Ports Available | EVs per Charger | Miles Per EV Charger | Rank Based on Miles Per EV Charger |
|---|---|---|---|---|---|---|---|
| **Illinois** | **26,000** | **4,286,622** | **0.61%** | **2,287** | **11.37** | **63.81** | **27** |
| Michigan | 10,620 | 2,810,414 | 0.38% | 1,694 | 6.27 | 72.13 | 30 |
| Indiana | 6,990 | 2,183,343 | 0.32% | 834 | 8.38 | 116.19 | 34 |
| Iowa | 2,260 | 1,210,633 | 0.19% | 534 | 4.23 | 214.99 | 45 |



Illinois Charging Station Locations



*Source: Electrek.co, Department of Energy Alternative Fuels Data Center*

# Illinois Automotive Supply Base Risk Assessment

# BEV Drivetrain

## Important USD-Content Implications for Suppliers


ICE Example @ $35,000 MSRP Passenger Car

### Major Systems Affected by Transitioning to BEV

| | Est-USD Impact per Vehicle |
|---|---|
| Axles, driveshafts & auxiliary components (Reduced complexity) | ↓ $300 |
| Exhaust system (Eliminated) | ↓ $400 |
| Fuel system (Eliminated) | ↓ $500 |
| Transmission including clutches, planetary gears & torque converter (eliminated & replaced with electric drive unit & electric motors, 2 assumed in example but up to 4 possible) | ↓ $500 net |
| Engine (Eliminated) | ↓ $4,500 |
| Power electronics & high-voltage electrical architecture (Added) | $3,000 |
| Battery pack (Added) | $10,000 |
| Other systems affected including body structures (increased content), audio/infotainment (upgraded), braking (upgraded), climate control/HVAC (upgraded) | $2,000 |

*Insourcing Risk by Automakers*



*Source: BofA Global Research, Intellicosting LLC , Wolfe Research & CAR analysis; Note- For illustrative purposes & figures rounded. to the nearest $100 Light trucks & performance models could differ significantly.*

# Bill of Materials (BOM) – Risk Rankings – Highest Risk

| Risk Profile | Rank: | BOM Category: | Key Trends: |
|---|---|---|---|
| Highest Risk | #1 | Engine Components | Displaced by BEVs cost pressures to accelerate; consolidation likely |
| | #2 | Drivetrain – Transmission | Reduced dollar content/vehicle with electrified powertrain; |
| | #3 | Drivetrain – Axles, Driveshafts | Reduced dollar content/vehicle with an electrified powertrain |
| | #4 | Fuel System | Eliminated with BEVs; consolidation likely |
| | #5 | Exhaust/Emission Control | Eliminated with BEVs; consolidation and offshoring likely (after-market business model) |

*Source: CAR Analysis*

# Bill of Materials (BOM) – Risk Rankings – Low to Moderate Risk

| Risk Profile | Rank: | BOM Category: | Key Trends: |
|---|---|---|---|
| Low to Moderate Risk | #6 | Thermal Management – HVAC & Engine Cooling | Increased dollar content with electrified powertrain; consolidation likely |
| | #7 | Body/Chassis – Structural | Increased dollar content with electrified powertrain (higher vehicle weights, need to protect battery); consolidation likely |
| | #8 | Passenger Restraint / Passive Safety Systems | Already highly concentrated, further consolidation unlikely; restructuring expected |
| | #9 | Interior Systems | No meaningful changes from current practices expected |
| | #10 | Body/Chassis – Windows | Already highly concentrated, further consolidation unlikely |
| | #11 | Wheels/Tires | Already highly concentrated, further consolidation unlikely |
| | #12 | Steering System | Already highly concentrated, further consolidation unlikely |
| | #13 | Suspension System | Increased dollar content with electrified powertrain (higher vehicle weights); already highly concentrated, further consolidation unlikely |
| | #14 | Braking | Increased dollar content with electrified powertrain (regenerative braking); potential for high growth by more complex systems |



*Source: CAR Analysis*

# Bill of Materials (BOM) – Risk Rankings – Growth Opportunities

| Risk Profile | Rank: | BOM Category: | Key Trends: |
|---|---|---|---|
| **Growth Opportunities** | #15 | Electronics & Electrical – ADAS & Automation | High growth potential; large total addressable market; falling piece prices |
| | #16 | Audio & Telematics | High growth potential / increasing market penetration; already highly concentrated, further consolidation unlikely |
| | #17 | Vehicle Electrification–Electric/Drive/Motors | Displacing ICE transmission; select insourcing my automakers; scale hurdles for small/mid suppliers |
| | #18 | Vehicle Electrification–Power Electronics & Other | Displacing ICE transmission components |
| | #19 | Electronics & Electrical | Growing dollar content per vehicle with high-powered wiring architecture |
| | #20 | Vehicle Electrification–Battery Pack Assembly | Displacing ICE; falling piece price but growing total addressable market |
| | #21 | Vehicle Electrification–Battery Cells | Displacing ICE; falling piece price but growing total addressable market |



*Source: CAR Analysis*

# Bill of Materials – Illinois Risk Rankings

| Risk Profile | Category | Establishments | | | | Employment | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | High Risk | Moderate Risk | Low Risk | Overall | High Risk | Moderate Risk | Low Risk | Overall |
| Moderate Risk | Aftermarket | | 32 | | 32 | | 1,044 | | 1,044 |
| High Risk | Axle, Brake, and Body Control | 23 | | | 23 | 2,417 | | | 2,417 |
| Moderate Risk | Body and Exterior | | 39 | | 39 | | 8,360 | | 8,360 |
| Growth | Clean Energy System | | | 43 | 43 | | | 7,590 | 7,590 |
| Moderate Risk | Climate Control | | 6 | | 6 | | 546 | | 546 |
| High Risk | Drive Train | 21 | | | 21 | 2,019 | | | 2,019 |
| Growth | Driving Support and Telematics | | | 12 | 12 | | | 1,302 | 1,302 |
| Growth | Electrical and electronics | | | 184 | 184 | | | 10,566 | 10,566 |
| High Risk | Engine and Engine Parts | 56 | | | 56 | 6,382 | | | 6,382 |
| Growth | Engineering Service | | | 19 | 19 | | | 821 | 821 |
| Moderate Risk | Interior | | 25 | | 25 | | 2,398 | | 2,398 |
| Moderate Risk | Metalworking, Stamping, Machining | | 440 | | 440 | | 18,564 | | 18,564 |
| Moderate Risk | Motor Vehicle Manufacturing Equipment | | 26 | | 26 | | 1,265 | | 1,265 |
| Moderate Risk | Motor Vehicles Assembly | | 8 | | 8 | | 13,094 | | 13,094 |
| Growth | Research and Development | | | 1 | 1 | | | 10 | 10 |
| Moderate Risk | Small and General Parts | | 91 | | 91 | | 5,185 | | 5,185 |
| Moderate Risk | Suspension and Steering | | 47 | | 47 | | 7,496 | | 7,496 |
| Overall | | 100 | 714 | 259 | 1,073 | 10,818 | 57,952 | 20,289 | 89,059 |



*Source: CAR Analysis*

# Illinois Employment and Company Risk Assessment

- High Risk – Engines and Engine Parts, Drivetrain, Axle, Fuel Systems, Exhaust Systems
  - 10,800 employment (12.1%)
  - 100 establishments and companies (9.3%)
- Low to Moderate Risk – HVAC, Body & Exterior, Interior, Wheel/Tire, Steering and Suspension, Aftermarket, Metalworking, Stamping, Machining, Molding, Equipment Manufacturing, Assembly, General Parts,
  - 58,000 employment (65.1%)
  - 714 establishments and companies (66.5%)
- Growth Opportunities – Electrical and Electronics, Clean Energy Systems, Driving Support, Sensors, Engineering Service, Research and Development
  - 20,300 employment (22.8%)
  - 259 establishments and companies (24.1%)

# Recommendations and Conclusions

# Electrification: Top Five Recommendations for Illinois Stakeholders

- Take action based on CAR's Illinois automotive supplier analysis
  - Highest Risk: assist with product transition
  - Low to Moderate Risk: nurture
  - Growth Opportunities: assist existing firms in expansion, pursue new investment from similar firms
- Diversify existing battery supply chain to include cathodes and advanced battery materials, e.g. solid-state components
- Target battery assembly plant to serve as anchor for battery supplier ecosystem
- Leverage Rivian assembly plant to established localized battery supply chain
- Streamline residential/commercial building codes and utility regulatory policy to encourage EV charger adoption, to support infrastructure build-out and EV adoption

# Electrification: Top Five Illinois Opportunities

- Capitalize on growth potential of the 259 Illinois companies in growth product areas (over 20,000 Illinois employees), e.g. electrical and electronics, driving support and telematics, clean energy and engineering services
- Rivian assembly plant is an opportunity to establish localized battery supply chain
- Support additional investment by existing Illinois battery supplier companies within anode materials, graphite (including graphite-alternatives and additives), and electrolytes
- Develop supporting ecosystem for anodes and electrolytes by attracting sub-
- component suppliers, e.g. battery materials processors
- Foster regional ties with other state governments to encourage battery ecosystem development and advanced R&D activities
- Streamline residential/commercial building codes and utility regulatory policy to encourage EV charger adoption, to support infrastructure build-out and EV adoption

# Electrification: Top Five Concerns

- No major battery assembly plants announced in Illinois so far (they are becoming anchors for battery supplier parks in some cases, and centers of battery supplier ecosystems)
- Lack of battery assembly plants may limit opportunities to lure full-service battery recycling companies to collection facilities-only (lower value add)
- No cathode plants, which account for approximately 50% of battery cost – an important driver of localized content to meet proposed IRA content requirements
- Traditional ICE powertrain suppliers (transmissions, engines, and related subsystems) to consolidate, and could become "distressed" assets during electrification transition
- Advanced R&D battery activities currently focused on anodes and graphite applications – important growth opportunities but may be insufficient without additional investment within other areas

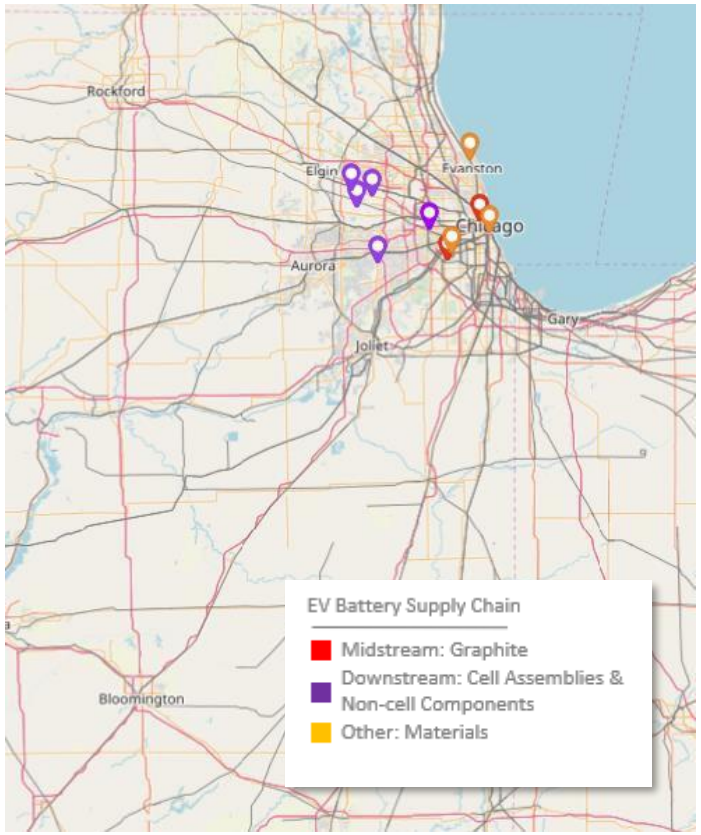
# Inflation Reduction Act: Implications and Opportunities for Illinois

- Balance of policy supporting electrification and North American manufacturing
- The resulting anticipated growth in U.S. EV supply chain is an opportunity for existing Illinois companies and for the attraction of new firms to the state
- Near-term: expand existing supply base for electrolytes and anode materials
- Medium and Long-term: attract localized battery supply for Rivian (currently source cells
- from Korea) and potentially cathodes (no plants currently exist in North America)
- Battery content requirements likely biggest source of opportunity for Illinois
- 2024: 40% of content from NA or Free Trade Agreement (FTA) countries
- 2029: 100% of content from NA or Free Trade Agreement (FTA) countries
- Long-term content requirements will be challenging for automakers without substantial additional investment in localized North American supply chain (only Tesla, GM, and Ford have publicly announced plans so far for cathode manufacturing in North America)

# Conclusions and Recommendations

## Investment Opportunities – EV Supply Chain

*Illinois Battery Supply Chain Locations – Current*




** Other materials include battery-grade graphite, used in anode manufacturing*

- Existing facilities are well positioned to benefit under the Inflation Reduction Act (IRA), to meet localized battery materials content requirements
- Automakers appear to be prioritizing "shovel-ready" supply chain projects, and may need to leverage existing supply chain infrastructure to launch key BEV programs on time
- Illinois can leverage existing supply chain endowment, including:
  - Electrolyte manufacturing facilities – Honeywell
  - Graphite, battery-grade materials manufacturing – Superior Graphite*
  - Advanced battery materials R&D – Nanograf, Superior
  - Graphite, and Volexion
- Opportunities to expand existing supply chain footprint to meet improving demand outlook for battery materials

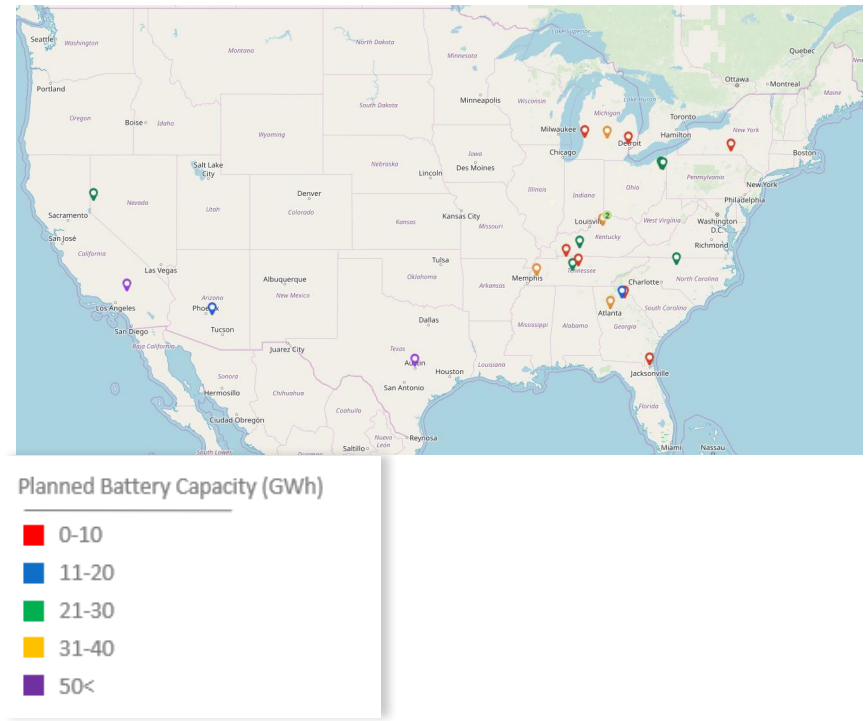


*Source: NAATBATT and CAR analysis*

# Conclusions and Recommendations

## Challenges – EV Supply Chain

*Battery Cell Assembly Plants – Announced*




- Battery cell assembly plants are to become the anchors for battery supplier parks (in some cases) and the center for supplier ecosystems, generally speaking
- Automakers appear to be prioritizing "shovel-ready" battery assembly sites for new investment, most notably in Southern States
- Although having BEV assembly plants (Rivian) and existing materials suppliers, Illinois lacks a battery assembly plant
  - Full-service battery recyclers are locating near battery assembly plants to use waste as feed stock (subject to change when sufficient end-of-life BEVs become available within 12 years, as projected)
- Illinois lacks key suppliers of cathode materials, which account for as much of 50% battery cell' cost – an important driver of localized content to meet proposed IRA requirements

*Source: NAATBATT and CAR analysis*

# Conclusions and Recommendations

## Potential Product Shifts

- Products specific to ICE are at greatest risk, and have the least ability to shift into growth areas
  - Manufacturers for which these are secondary products might successfully retain business by pivoting to aftermarket products
  - Might also be able to pivot towards industrial, stationary, and off-road equipment
  - Manufacturers should secure a role in hybrid and plug-in hybrid propulsion system supply chain to maintain current products as long as possible during the transition period
- In Illinois, drivetrain, axle, fuel systems, exhaust systems, engines and engine parts are the most vulnerable industries and the most at risk in vehicle electrification transition. A total of 10,818 workers (12% of total employment) are employed by a total of 100 establishments in these categories.
- While the drivetrain industry is considered high risk, transmission parts suppliers may be able to retain business by serving electric vehicle 1-speed transmissions and e-transaxle units.
- Fuel systems manufacturing may find opportunity in fuel cells and hydrogen storage. In Illinois, the clean energy system industry is considered low risk and employs a total of 7,590 employees across 43 establishments.

# Conclusions and Recommendations

## Potential Product Shifts

- Battery heating and cooling; computer, electrical, and electronic system cooling; and passenger compartment heating and cooling may provide opportunities for specific parts currently produced for:
  - ICE thermal management
  - Engine and engine parts (manifolds, valves, pumps)
  - Fuel systems (tubing, pumps, filters)
- In Illinois, climate control is considered at moderate risk while engine and engine parts is at high risk in the transition to vehicle electrification. The climate control industry employs a total of 546 workers at 6 establishments.
- Lead acid battery manufacturing is poised to outright benefit from shifting to aftermarket
  - ICE phase-out will take decades
  - Higher margins in aftermarket offset loss of OEM sales

# Appendix

# Review of Illinois Automotive Industry – Methodology

- Ilinois' industry footprint is based upon a detailed review of the 2,608 business records with primary and secondary product information in IMAPC and MNI databases.
- CAR reviewed and identified each business' automotive product category through website information and private databases, and removed records that included closed locations, non-auto-related products, identical addresses, and duplications. As a result, a total of 854 business locations were identified as automotive-related entities.
- CAR incorporated these 854 business locations with another 219 locations identified from proprietary automotive supplier databases.
- The results show 1,073 business locations in the state of Illinois that supply or do business with the motor vehicle manufacturing industry.

# Review of Private Databases – Methodology

- Illinois' industry footprint is based upon a detailed review of the 2,608 business records with primary and secondary product information in IMAPC, Marklines, and MNI databases.
- CAR reviewed and identified each business' automotive product category through website information and private databases, and removed records that included closed locations, non-auto-related products, identical addresses, and duplications. As a result, a total of 854 business locations were identified as automotive-related entities.
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- The results show 1,073 business locations in the state of Illinois that supply or do business with the motor vehicle manufacturing industry.

# Public Database – Analysis

## Establishment, Employment, and Occupation

- Provides a complete count of establishments and employment in facilities with their primary activities in automotive industry
- Illinois' motor vehicle suppliers go beyond the traditional motor vehicle manufacturing sector as many serve multiple industries such as aviation, agriculture, energy, medical, appliance, locomotive, steel mills, electronics, and many more
- Public data *undercounts* Illinois' automotive footprint as it only captures firms listing automotive products as primary
- Illinois' state-wide occupational employment data is presented here, as industry-specific data suffers non-disclosure issues

# Public Database – Analysis

## Establishment, Employment, and Occupation

- In 2021, Illinois' automotive industry accounted for 381 establishments and employed 34,790 workers
  - Employment numbers were down by 5,078 from 2019. Most of the employment decline comes from automotive suppliers.
- Illinois automotive industry's average annual wage in 2021 was $61,178, down $2,789 from 2019, mainly due to motor vehicle output decline.
  - The average annual wage of Illinois' manufacturing sector was $79,409
- Illinois' employment in R&D applicable to auto and EV research is 107,690, though the distribution of these workers between various industries is not known. More than half of them are in software development occupations.

# Review of Private Databases

## Illinois Automotive and Related Industries

- Illinois' manufacturing establishments and employment skewed toward metalworking, machining, stamping, and molding industries.
  - They account for 41% of total establishments and 21% of employment in the database.
  - They also tend to be small by employment size. The average employees per establishment are 42, one of the smallest industry in the industry category; only aftermarket establishments are smaller.
- Motor vehicle manufacturing establishments on average are the largest employers in the database. They accounted for only 1% of total establishments, but employed 15% of workers. The average number of workers per establishment are 1,632.
  - Motor vehicle manufacturing equipment establishments are much smaller and are located near assembly plants in Illinois, Missouri, and Indiana.
- Electrical and electronic manufacturing establishments are the third largest industries in the database, accounting for 17% of total establishments and 12% of total employment. They are mostly located in Cook, DuPage, and Lake counties.

# Review of Private Databases (Continued)

## Illinois Automotive and Related Industries

- Body and exterior establishments account for 4% of total establishments, and 9% of employment. They do not necessarily locate at or near assembly plants because their products can be shipped economically.
- Interior parts establishments account for only 2% of total establishments and 3% of employment. Their products are usually bulky and fragile, and sometimes need to be produced in sequence. Their location are usually at or around assembly plants.
- Clean energy systems and driving support system establishments are mostly located in the Greater Chicago area. A few are near Rivian's assembly plant in Normal, IL. Clean energy systems account for 4% of total establishments and 9% of total employment.

# Review of Private Databases (Continued)

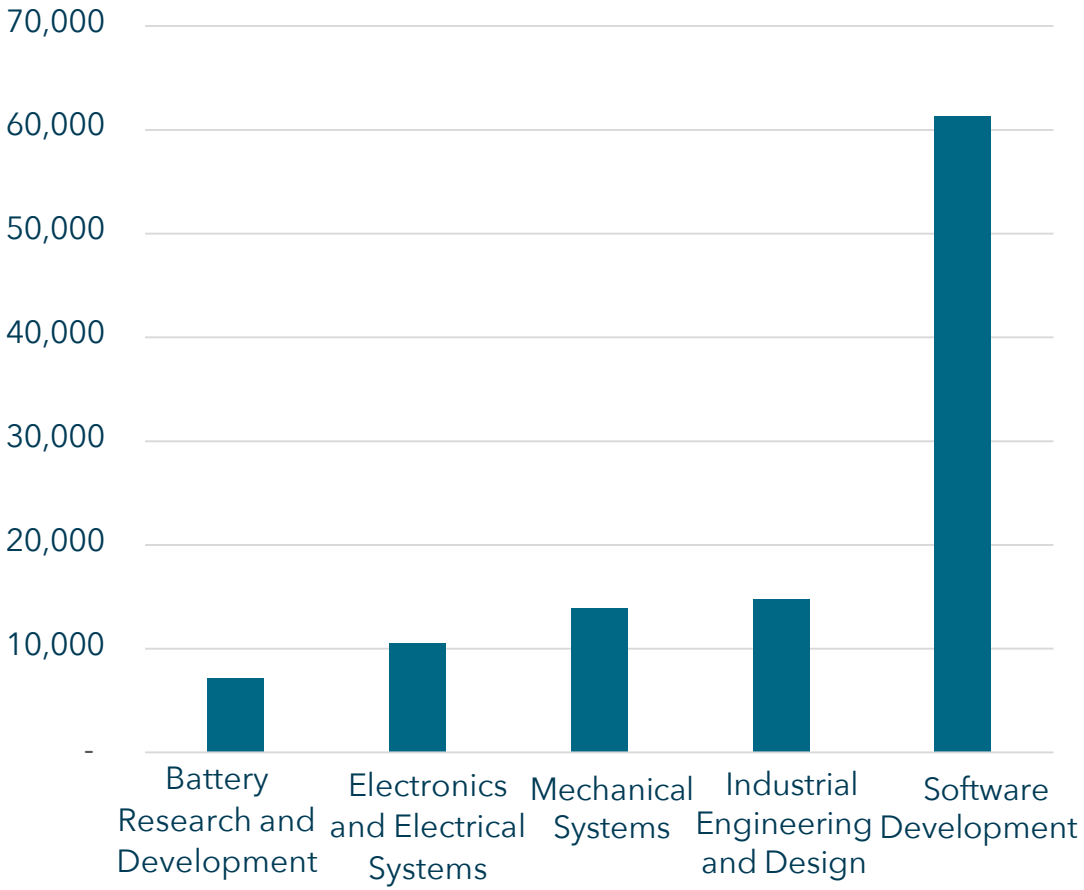
## Illinois Automotive and Related Industries

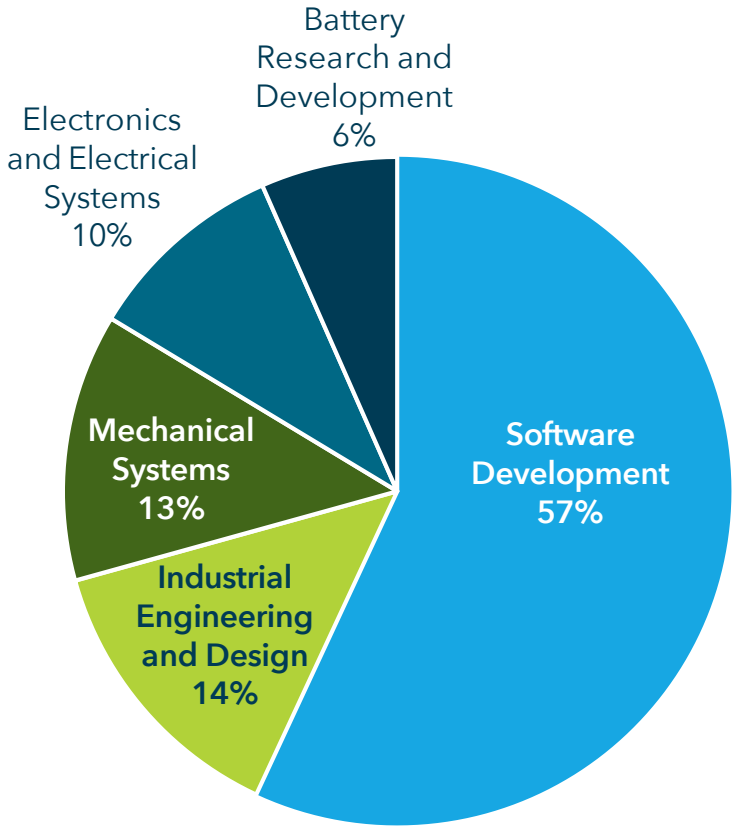
- Axle, brake, body control, steering, suspension, wheel, and tire establishments are located in the Greater Chicago and across the state of Illinois. Axle/brake/body control account for 3% of employment; Steering/suspension/wheel/tire account for 8% of employment.
- Engine and drivetrain account for 7% and 2% of employment, respectively. These two categories are the most vulnerable industries in vehicle electrification transition. A total of 8,401 workers are hired by a total of 77 establishments in engine and drivetrain categories.
- Small and general parts manufacturing establishments do not have clear clusters except for in the Greater Chicago area. They account for 8% of total establishments and 6% of total employment.

# Illinois Automotive Industry

- Publicly available data
  - Useful for trends and state-to-state comparisons
    - But undercounts total automotive presence because only primarily-automotive companies are included
- In 2021, Illinois' automotive industry accounted for 381 establishments and employed 34,790 workers
  - Resulting in Illinois being ranked 7th nationwide in terms of number of establishments and 10$^{th}$ nationwide in terms of employment
- Private database data
  - Captures a broader picture of the Illinois automotive endowment because it includes firms for whom automotive is a secondary, etc., business line
    - Using this data, CAR identified 1,073 automotive establishments in Illinois that employ 89,059 workers

# Occupational Employment in Illinois Related to Motor Vehicle, Battery, and Electric Vehicle Research, Design, and Product Development (2021)



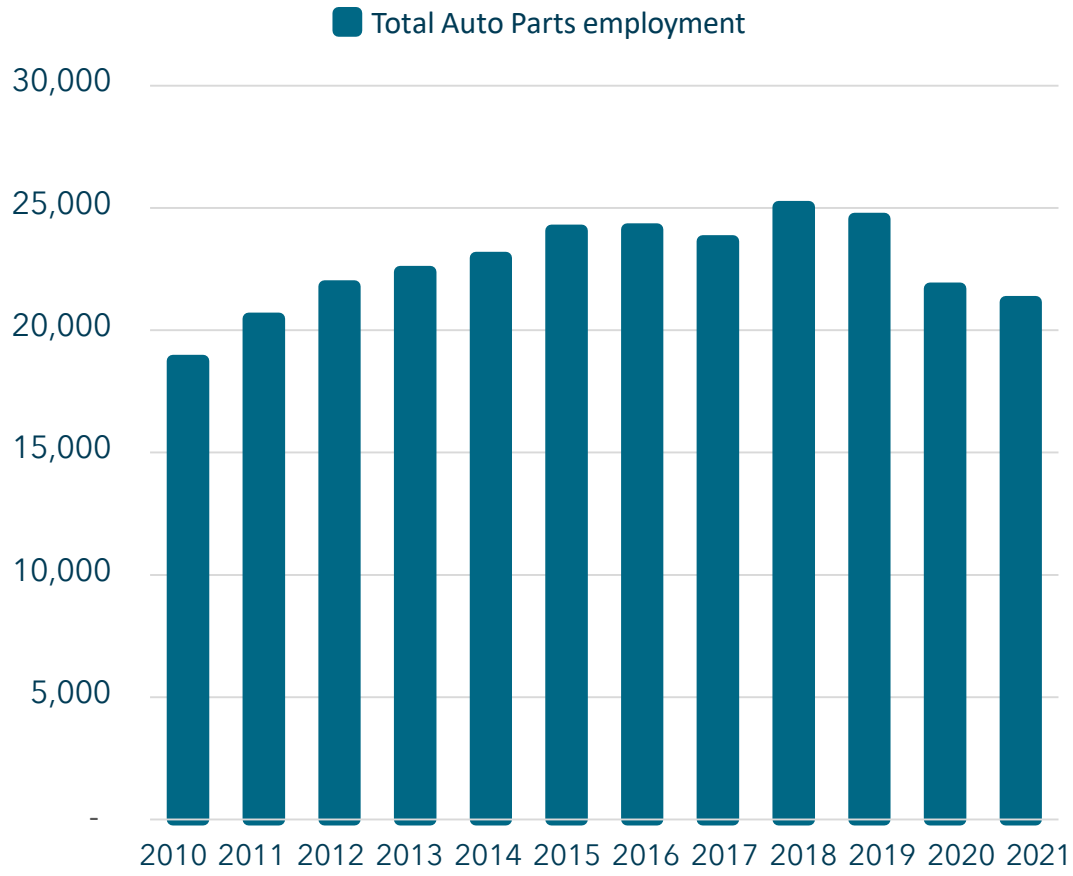



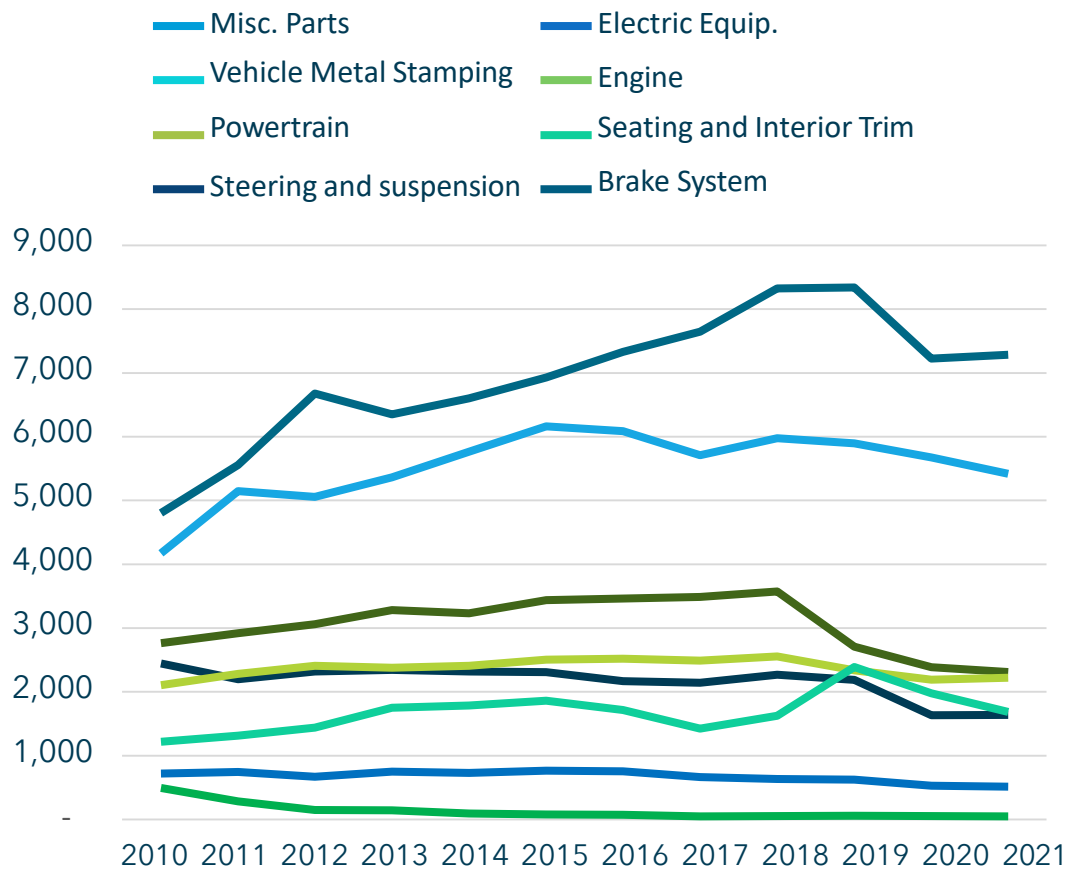



*Source: Bureau of Labor Statistics, Occupational Employment and Wage Statistics*

# Automotive Supplier Employment in Illinois

## 2010 –2021*




**2020 and 2021 numbers affected by pandemic and commodity shortages*



*Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages*

# Motor Vehicle and Parts Manufacturing in Illinois

| Motor Vehicle and Parts Manufacturing in Illinois | 2019 | 2020 | 2021 |
|---|---|---|---|
| **Total Employment** | **39,868** | **36,856** | **34,790** |
| Motor Vehicle | 11,810 | 11,901 | 10,383 |
| Bodies and Trailers | 3,502 | 3,256 | 3,256 |
| Vehicle Parts | 24,556 | 21,699 | 21,151 |
| **Total Establishments** | **368** | **364** | **381** |
| Motor Vehicle | 32 | 36 | 39 |
| Bodies and Trailers | 56 | 57 | 60 |
| Vehicle Parts | 280 | 271 | 282 |
| **Average annual wage per employee** | **63,966** | **60,106** | **61,178** |
| Motor Vehicle | $75,225 | $65,373 | $65,221 |
| Bodies and Trailers | $56,104 | $54,831 | $57,292 |
| Vehicle Parts | $59,673 | $58,009 | $59,791 |
| **Value of Shipments*** | **$27.1 billion** | **$24.4 billion** | *Not Available* |
| **Value Added*** | **$7.5 billion** | **$6.9 billion** | *Not Available* |

**Transportation Equipment*

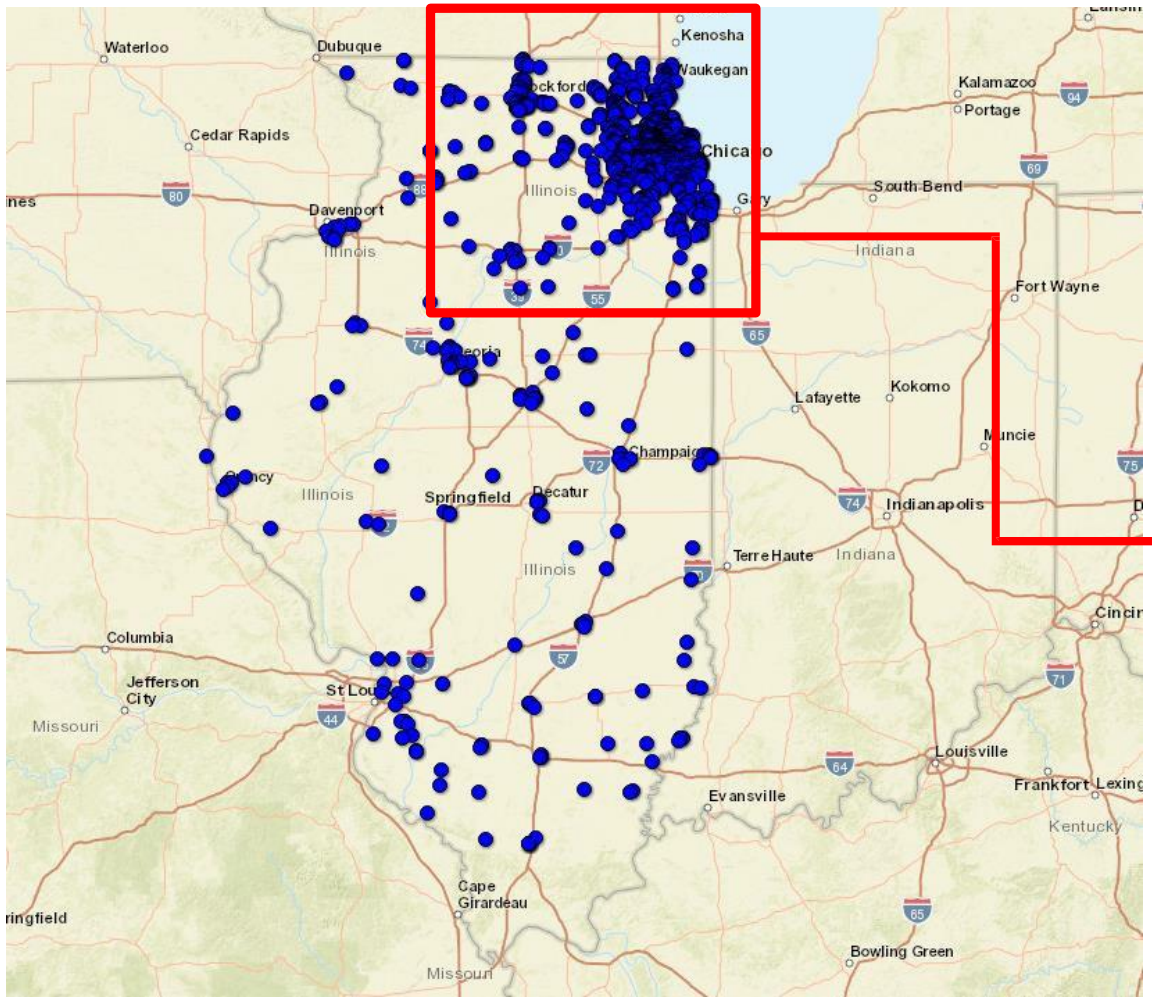


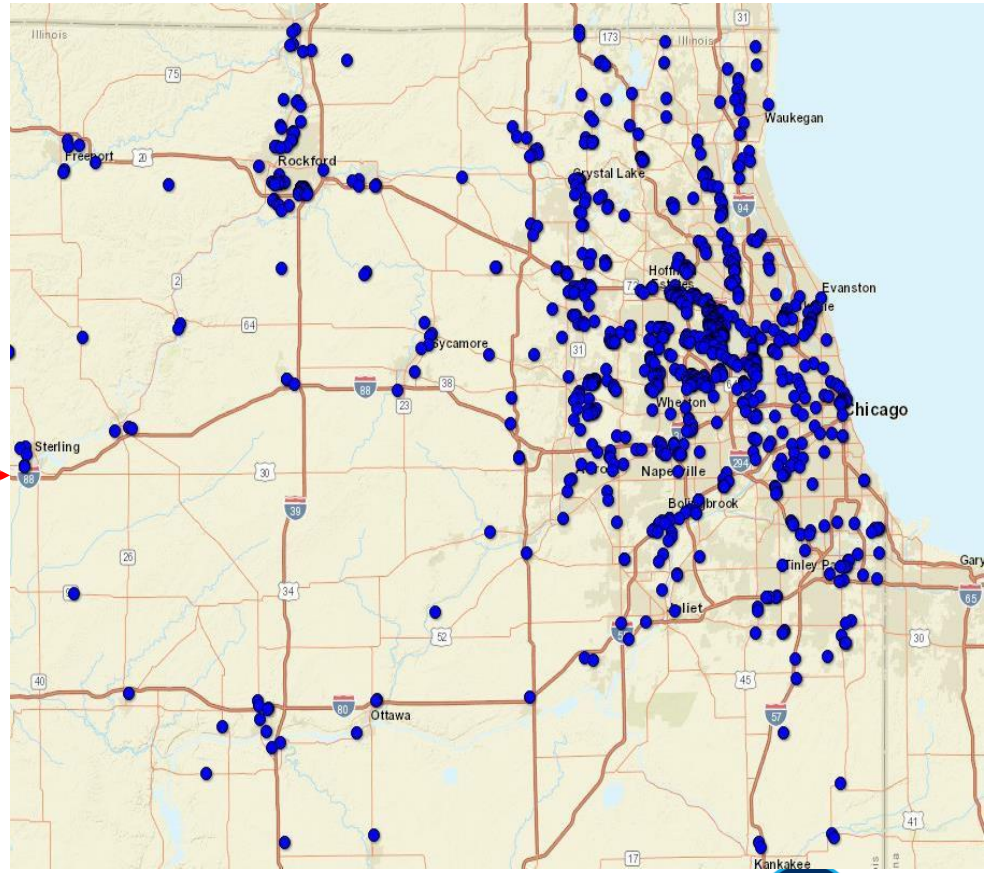
*Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Census, Annual Survey of Manufactures*

# Automotive Electrification Trends - Risk and Opportunities

- Since 2019, automaker investments in electrification have outpaced those in traditional Internal Combustion Engines (ICE)
  - The United States has captured the lion's share of North American EV investment
  - Illinois has captured $1.15 billion of EV investments since 2016, 1.4% of the U.S. total of $81.7 billion to date
  - Rivian was the first automaker to make an EV investment in Illinois, followed by Ford Motor Company (announced in 2019)
- NA electrified vehicle (HEV, PHEV, EV, FEV) production is forecast to increase from 2 million in 2022 to 7.5 million in 2029
  - Illinois electrified vehicle production is forecast to increase from about 60K in 2022 to just over 180,000 in 2029
  - 96% of vehicles produced in Illinois in 2022 were ICE, forecast to decrease to 54%, roughly in line with NA trends

# Illinois Automotive and Related Industries Locations - Overview

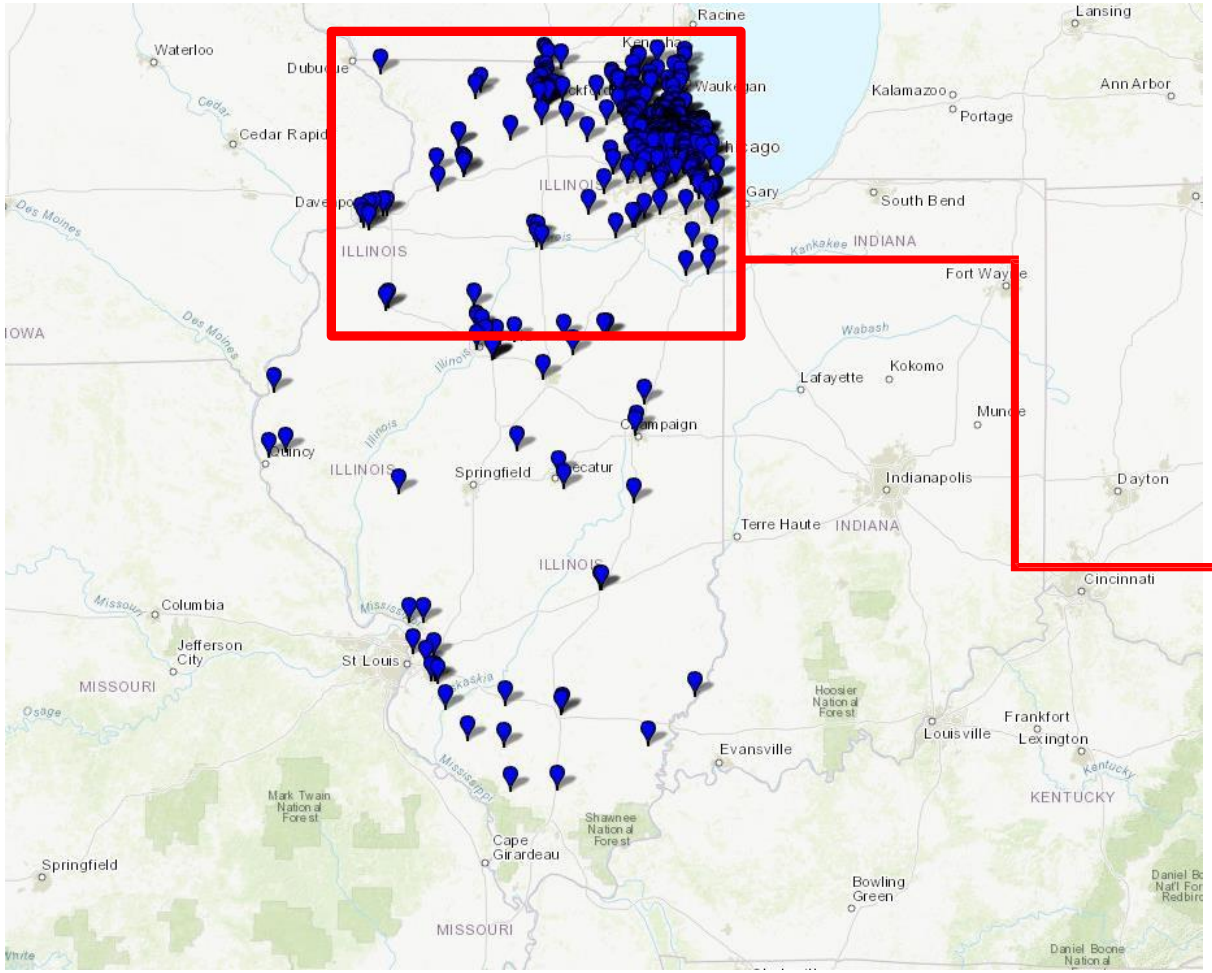


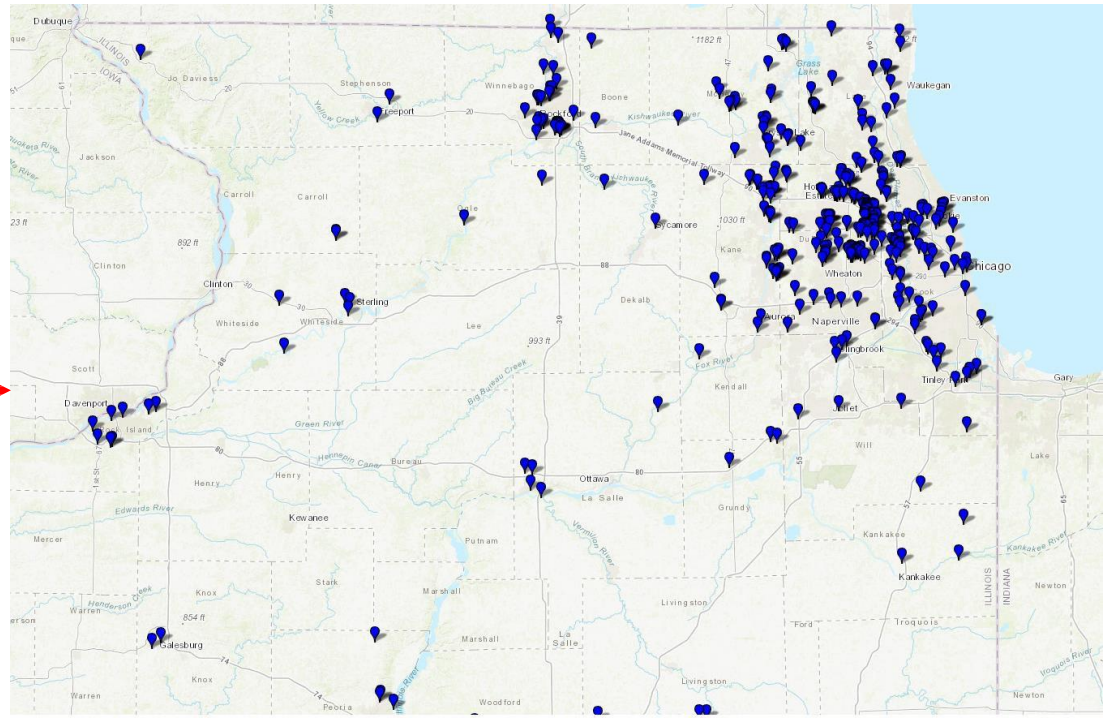




CENTER FOR AUTOMOTIVE RESEARCH

*Source: Center for Automotive Research*

# Illinois Automotive and Related Industries Locations – Metalworking, Stamping, Machining, Molding



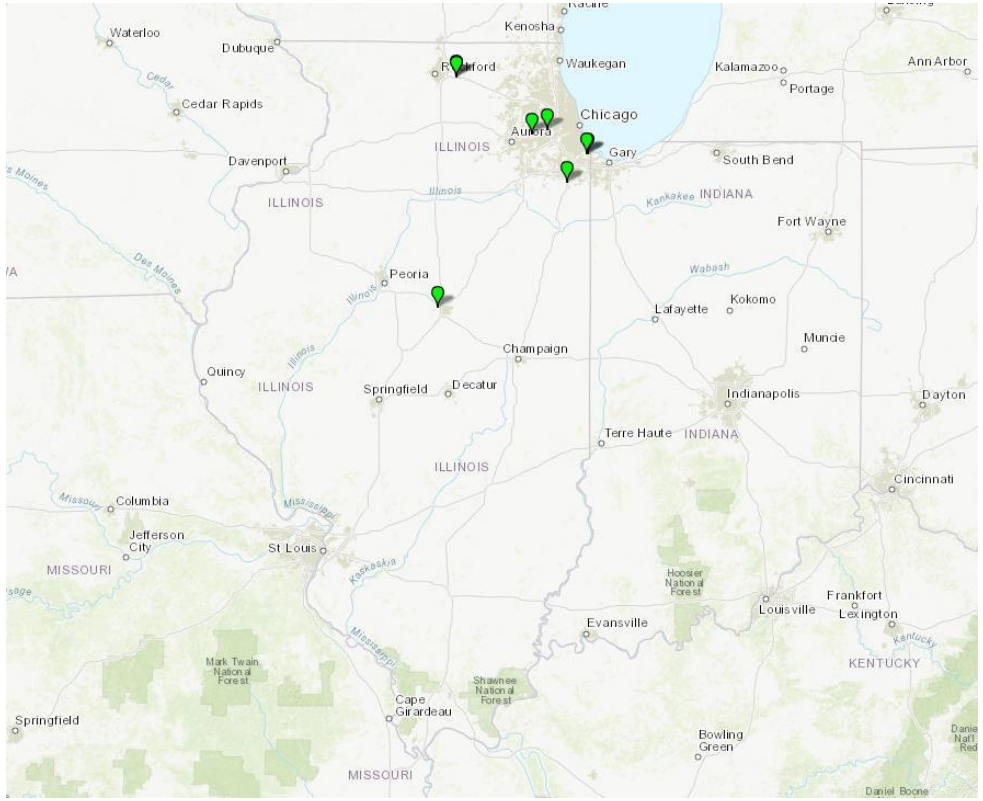




CENTER FOR AUTOMOTIVE RESEARCH

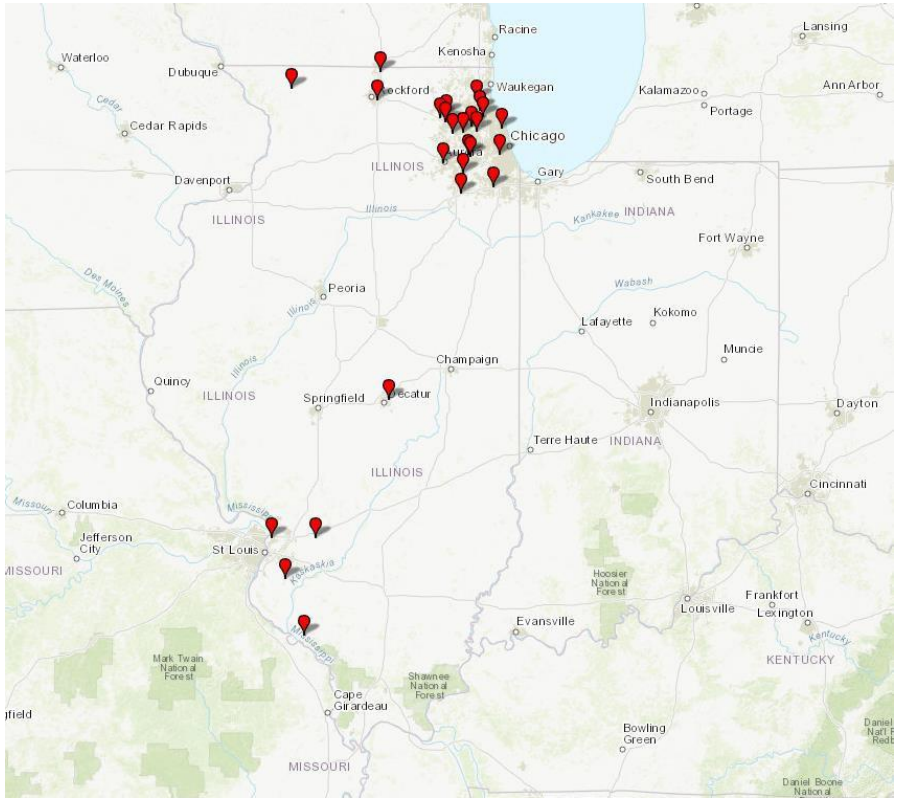
*Source: Center for Automotive Research*

# Illinois Automotive and Related Industries Locations – Motor Vehicle Assembly and Assembly Equipment

*Motor Vehicle Assembly*




*Motor Vehicle Assembly Equipment*

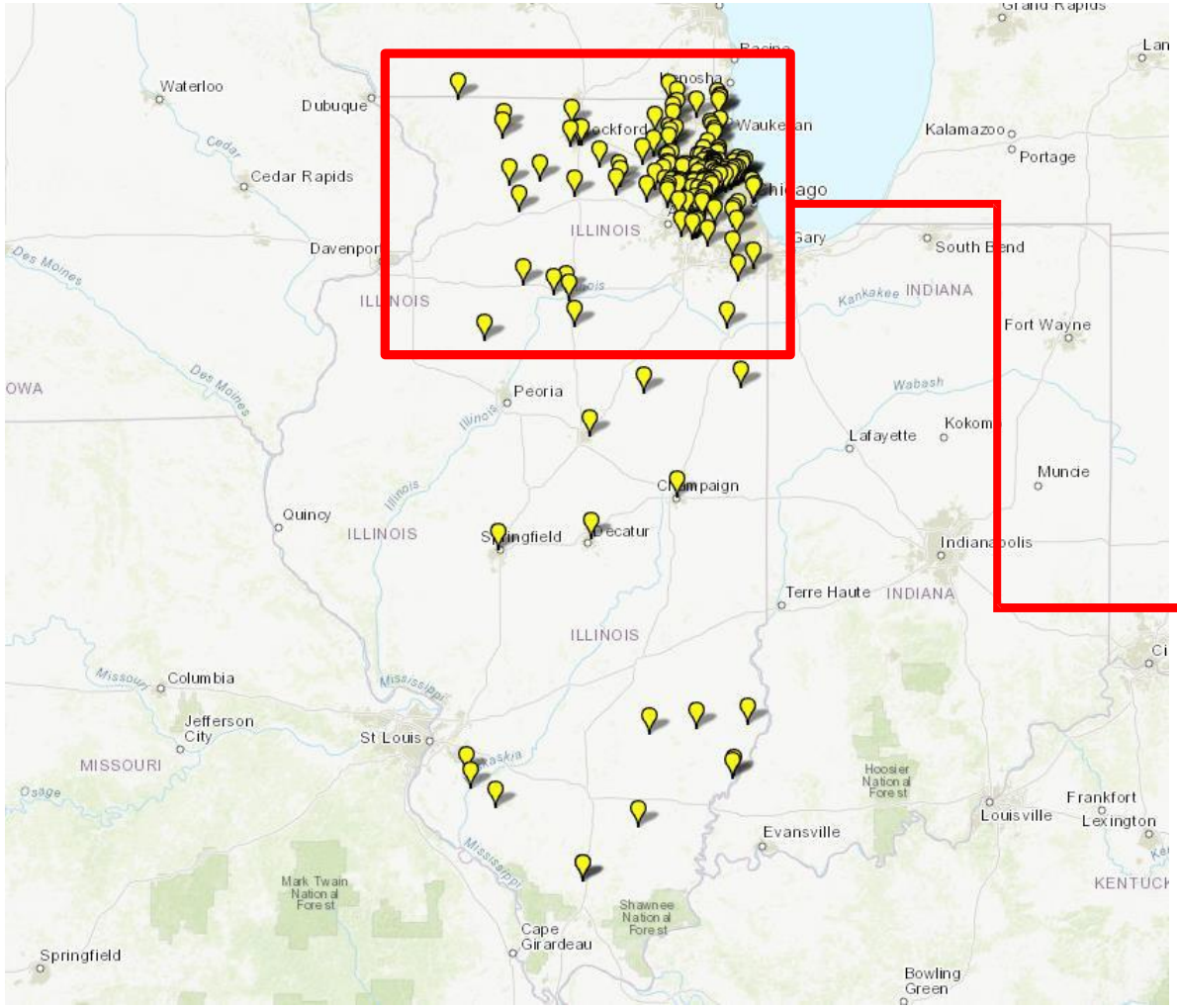


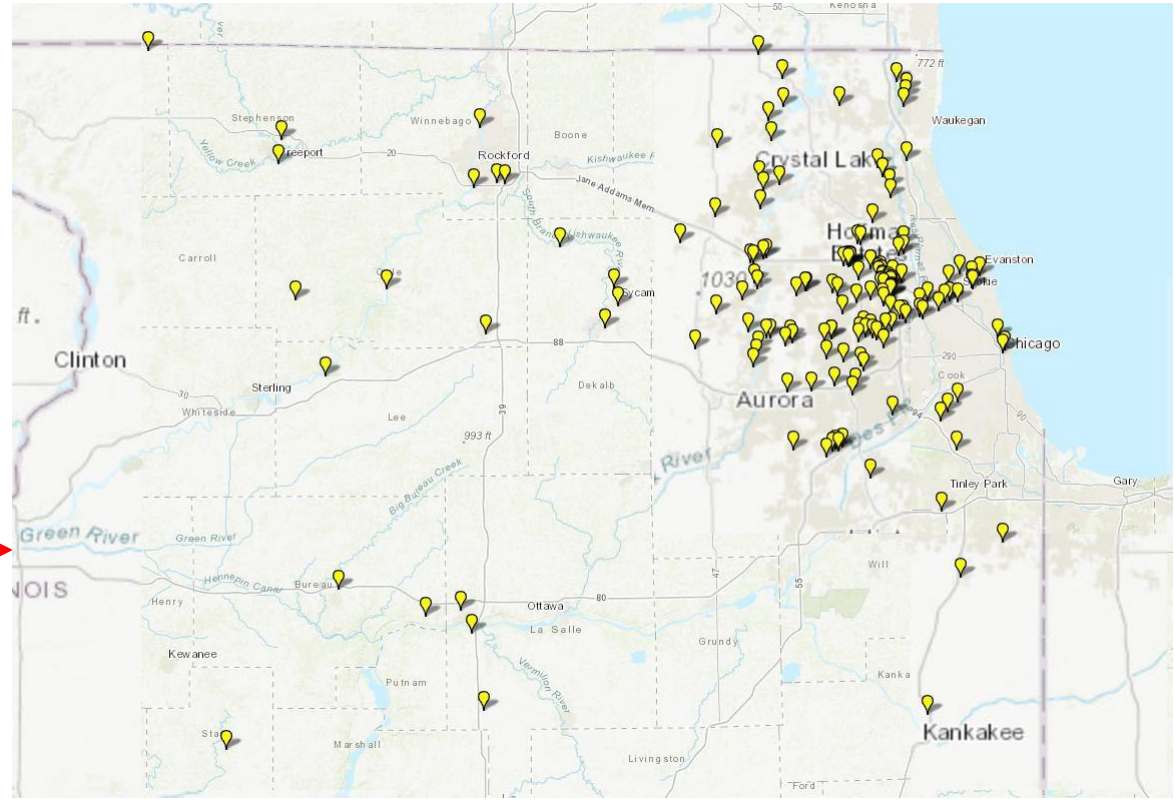

CENTER FOR AUTOMOTIVE RESEARCH



*Source: Center for Automotive Research*

# Illinois Automotive and Related Industries Locations – Electrical and Electronics



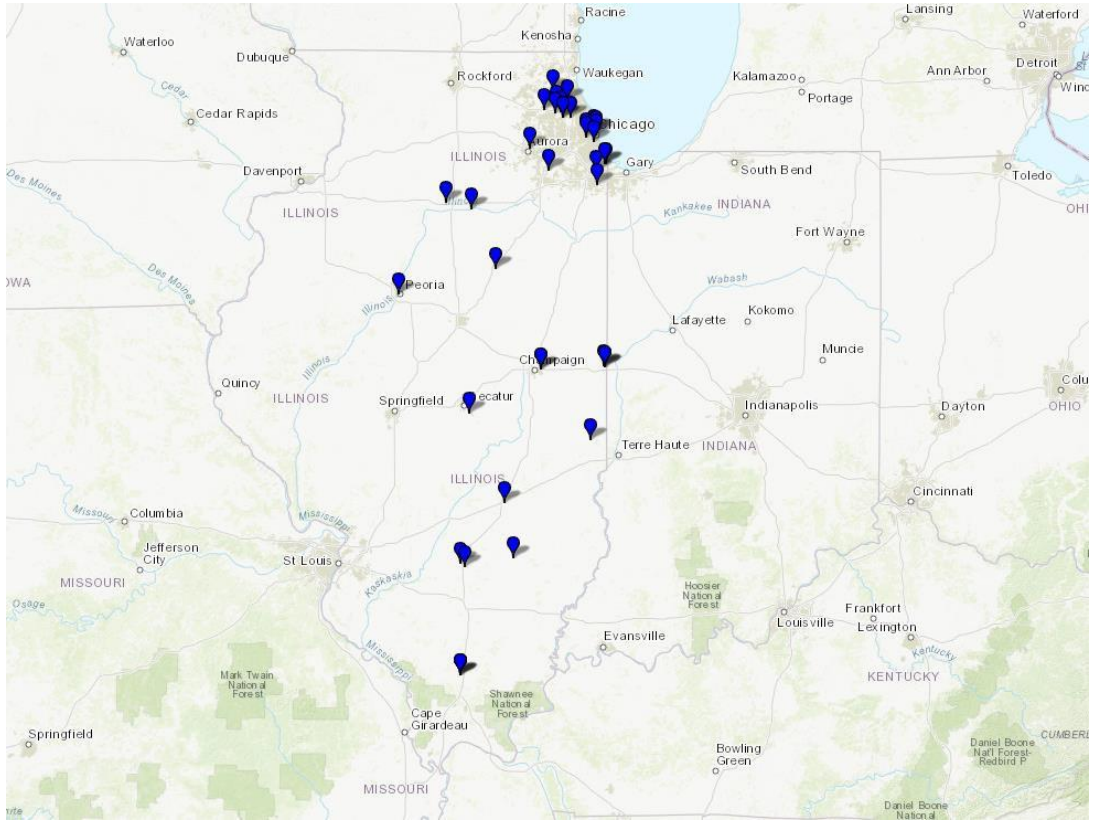




CAR CENTER FOR AUTOMOTIVE RESEARCH

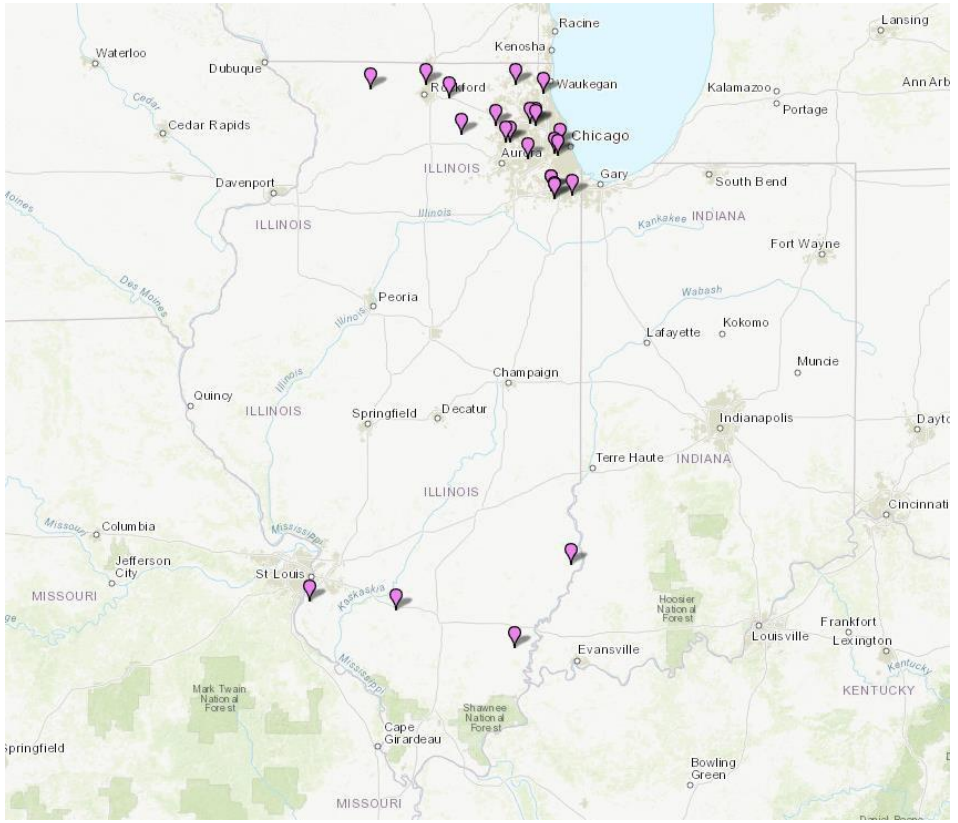
*Source: Center for Automotive Research*

# Illinois Automotive and Related Industries Locations – Body and Exterior; and Interior

*Body and Exterior*




*Interior*



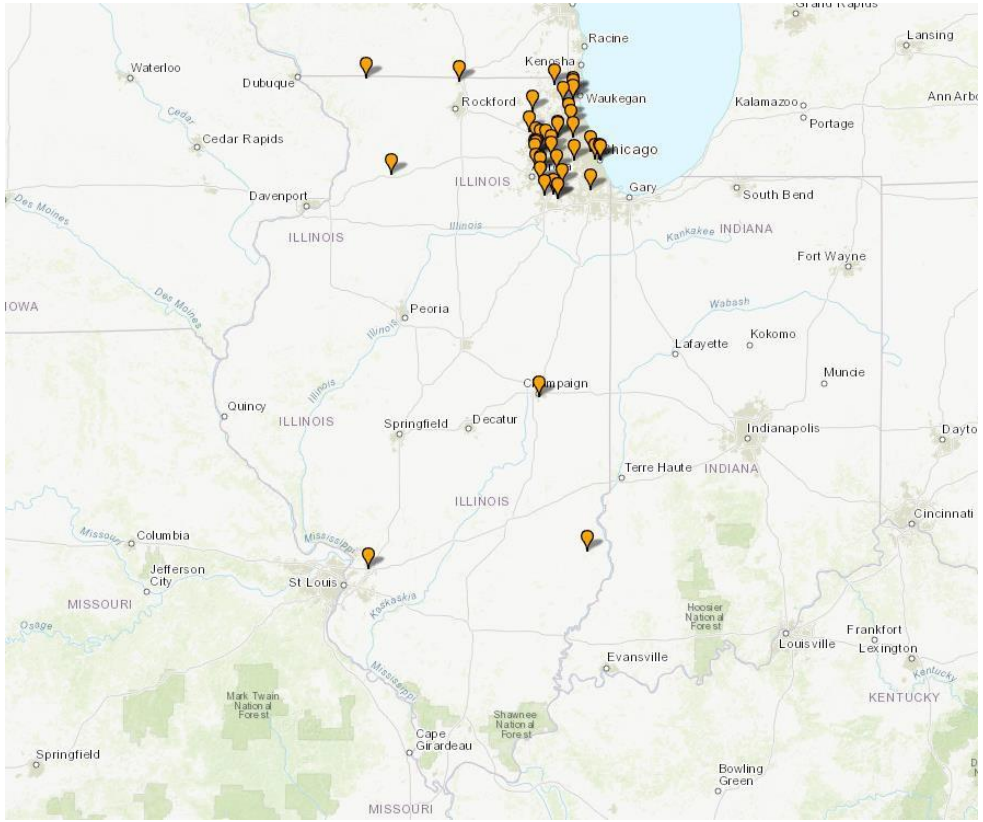

CENTER FOR AUTOMOTIVE RESEARCH



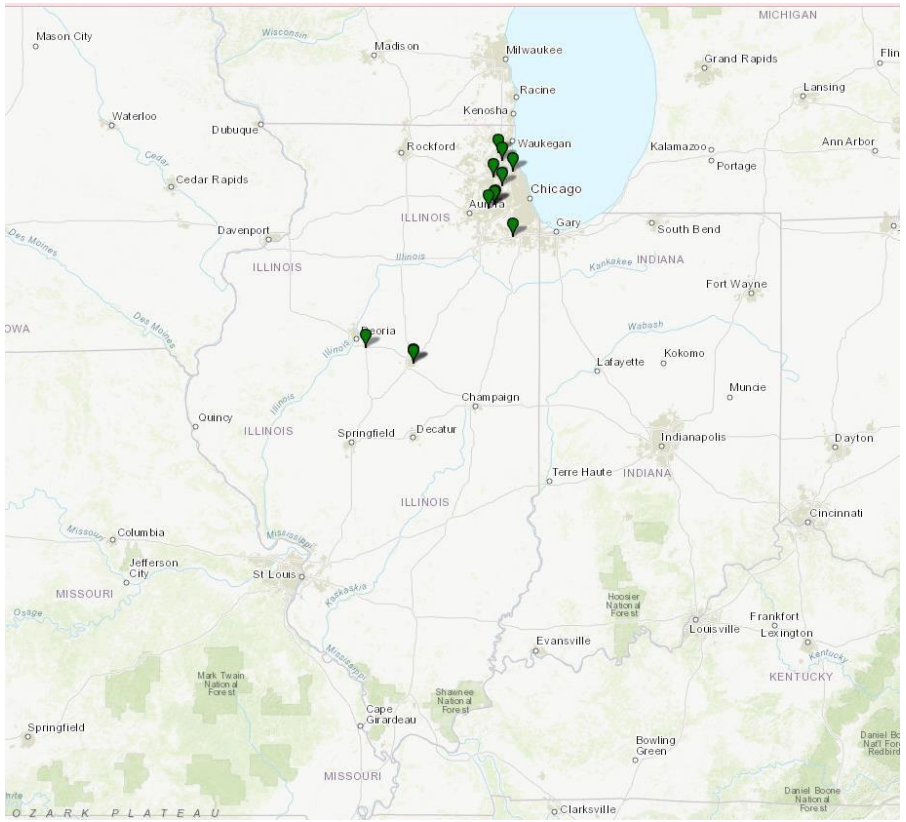
*Source: Center for Automotive Research*

# Illinois Automotive and Related Industries Locations – Clean Energy Systems; and Driving Support Systems

*Clean Energy Systems*




*Driving Support Systems*



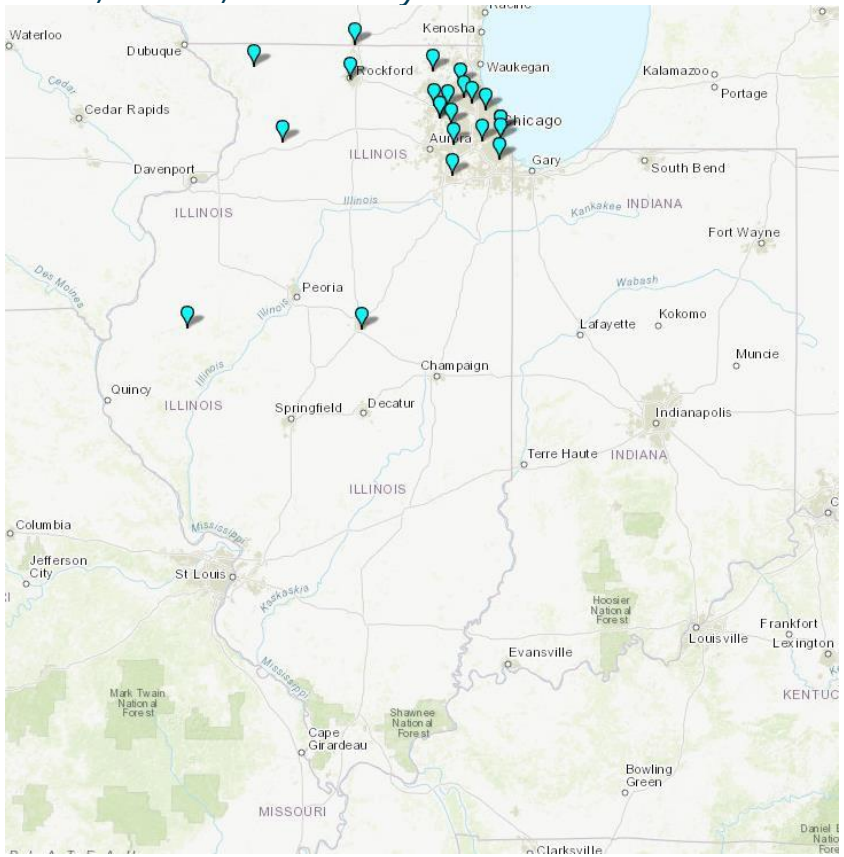

CENTER FOR AUTOMOTIVE RESEARCH



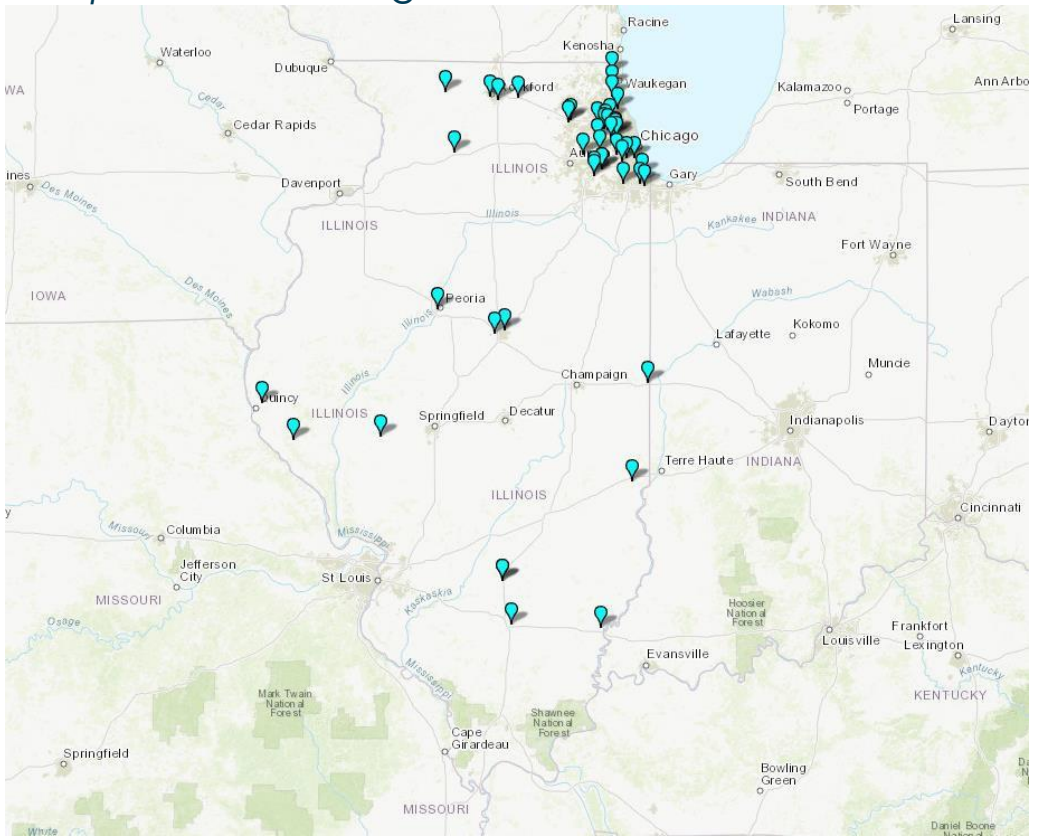
*Source: Center for Automotive Research*

# Illinois Automotive and Related Industries Locations – Axle, Brake, and Body Control; and Suspension, Steering, Wheel, and Tire

*Axle, Brake, and Body Control*




*Suspension, Steering, Wheel, and Tire*



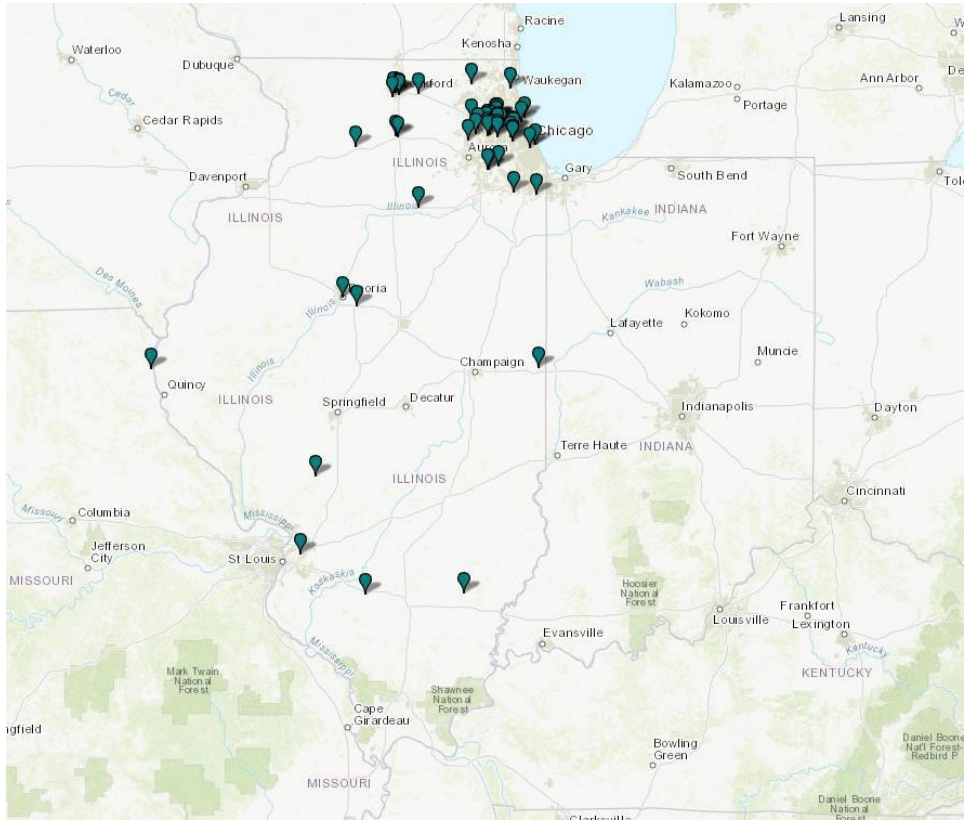

CENTER FOR AUTOMOTIVE RESEARCH



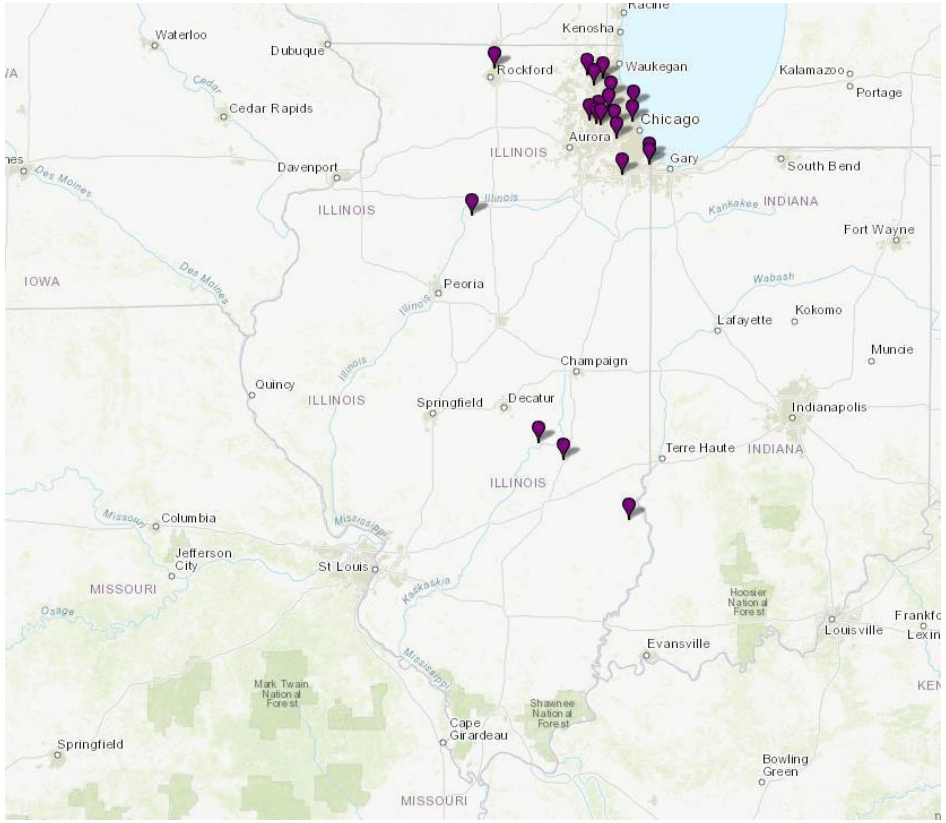
*Source: Center for Automotive Research*

# Illinois Automotive and Related Industries Locations – Engine and Engine Parts; and Drivetrain

*Engine and Engine Parts*




*Drivetrain*

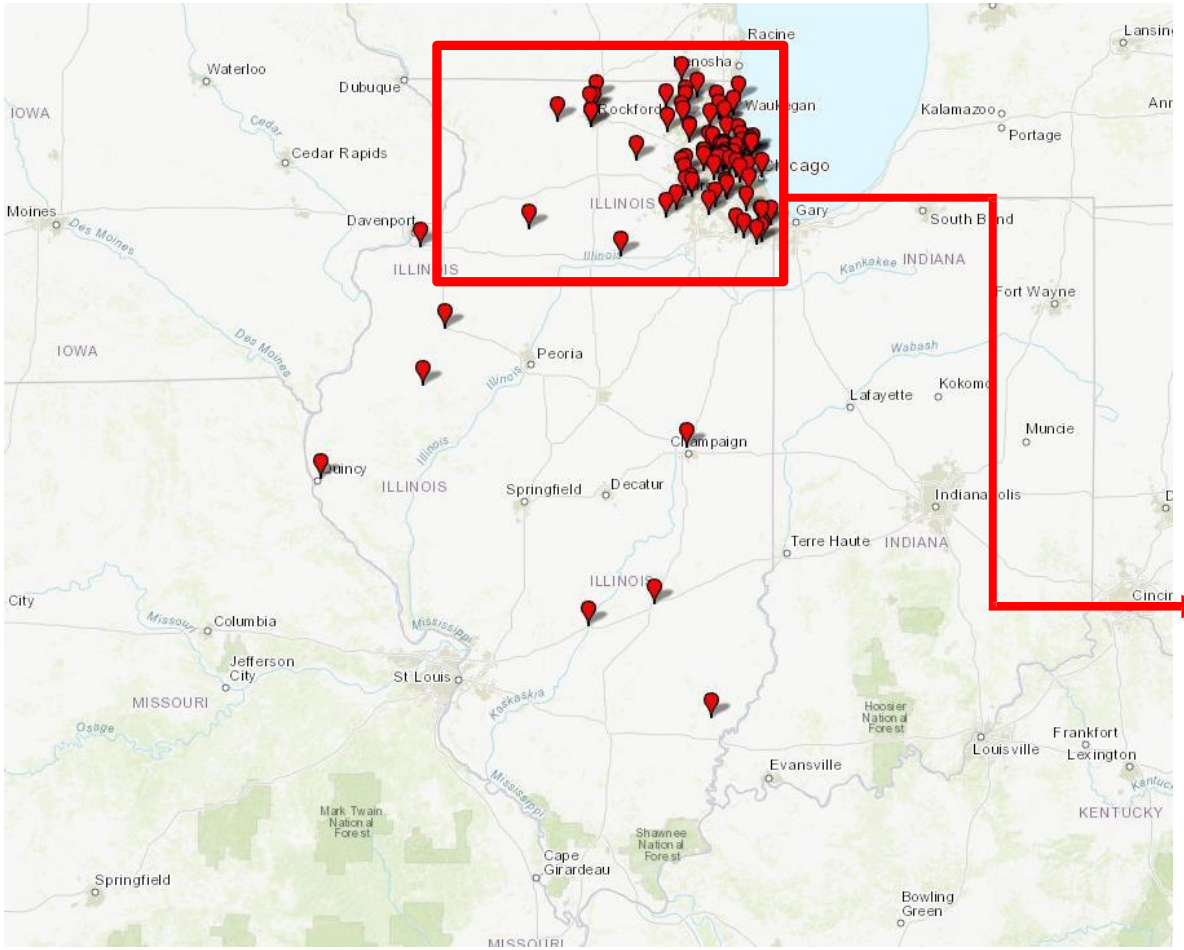


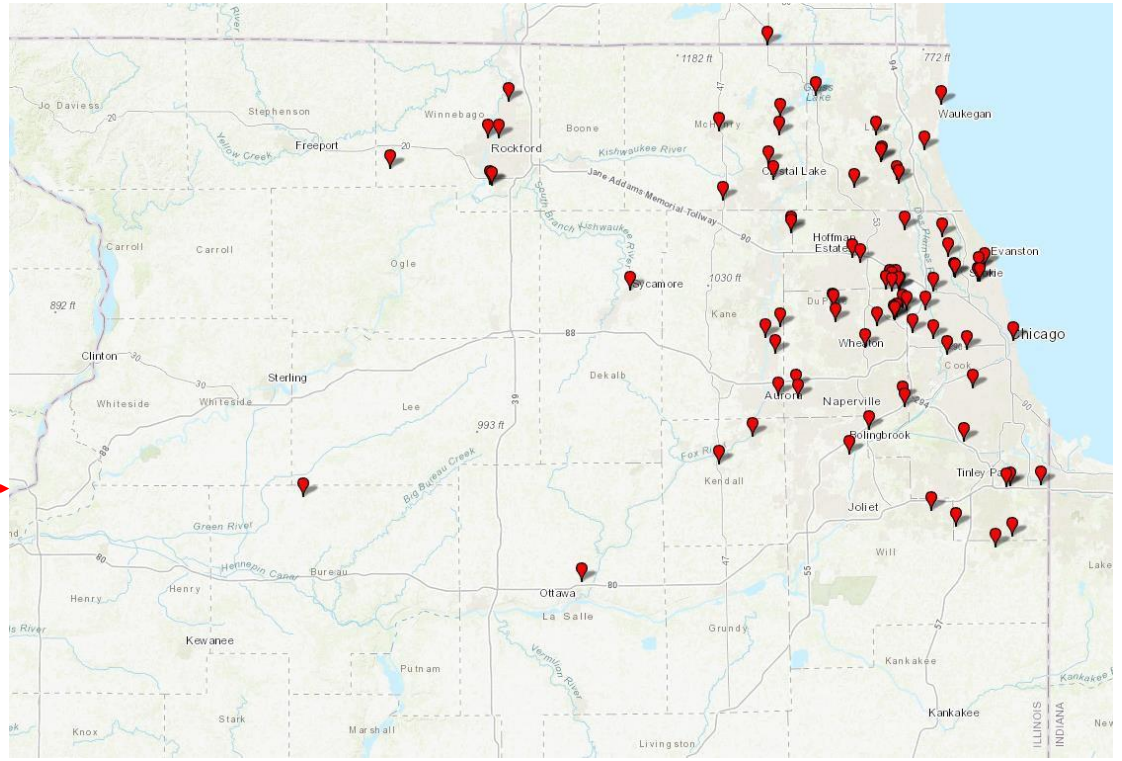

CENTER FOR AUTOMOTIVE RESEARCH



*Source: Center for Automotive Research*

# Illinois Automotive and Related Industries Locations – Small and General Parts



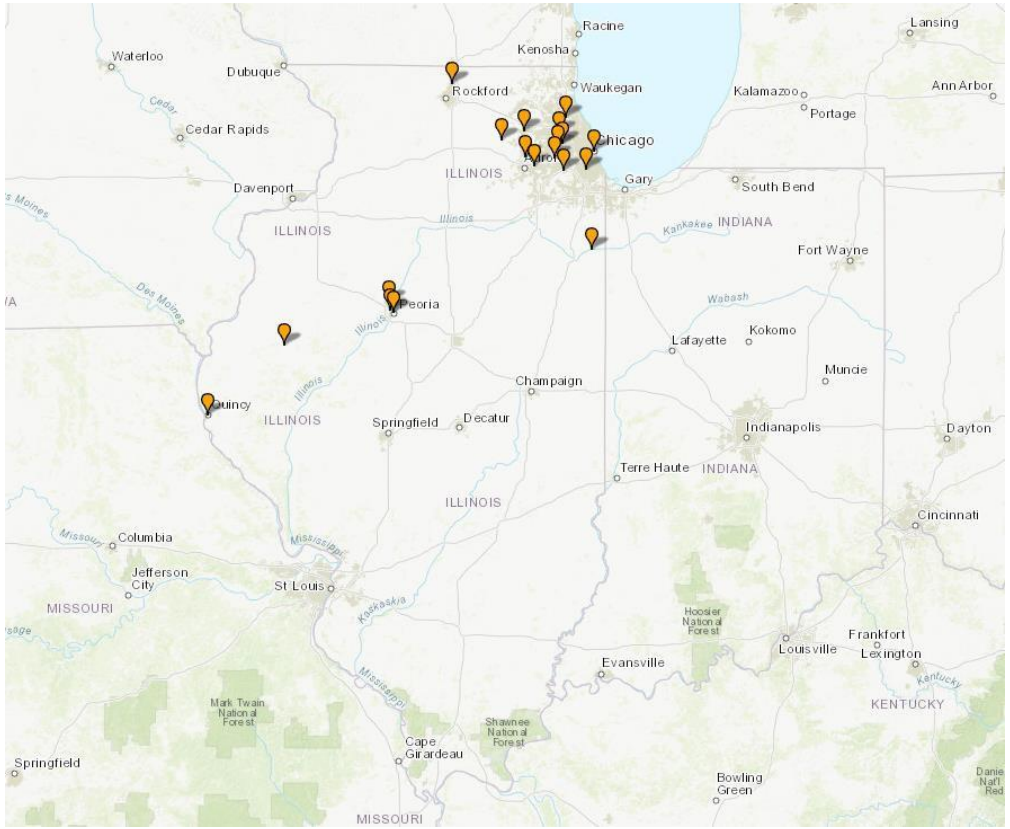

CAR CENTER FOR AUTOMOTIVE RESEARCH



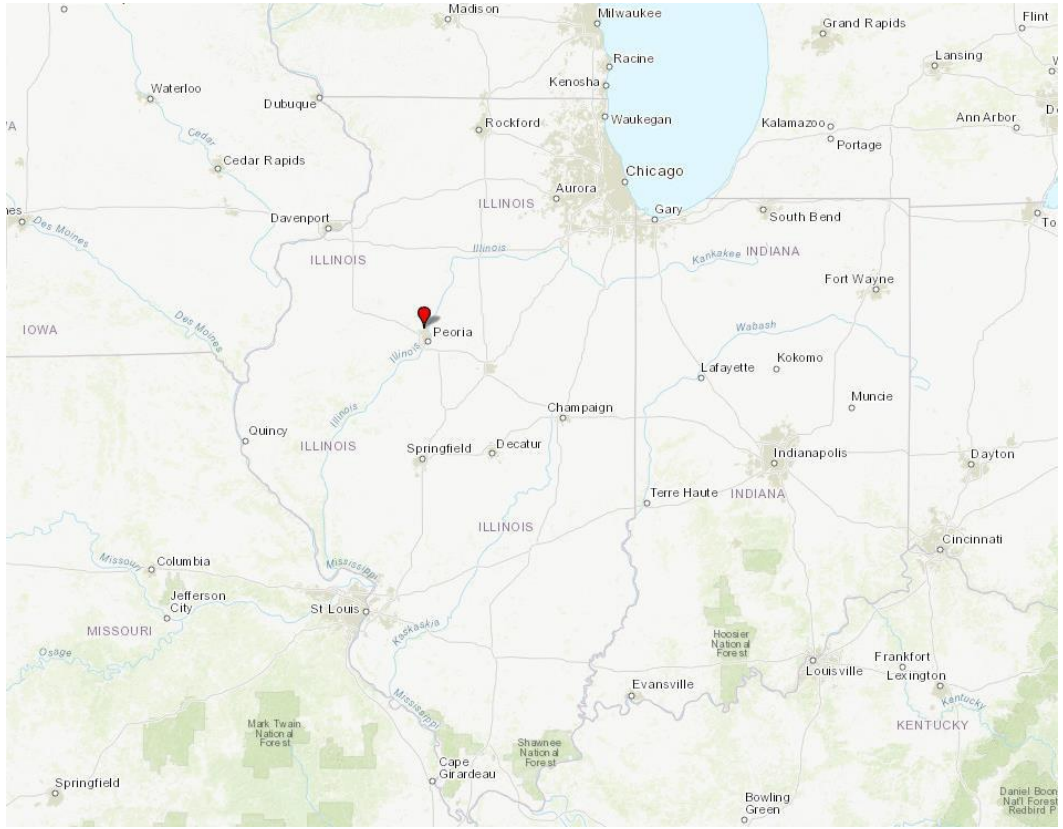
*Source: Center for Automotive Research*

# Illinois Automotive and Related Industries Locations – Engineering Service; and Research and Development

*Engineering*




*Research and Development*



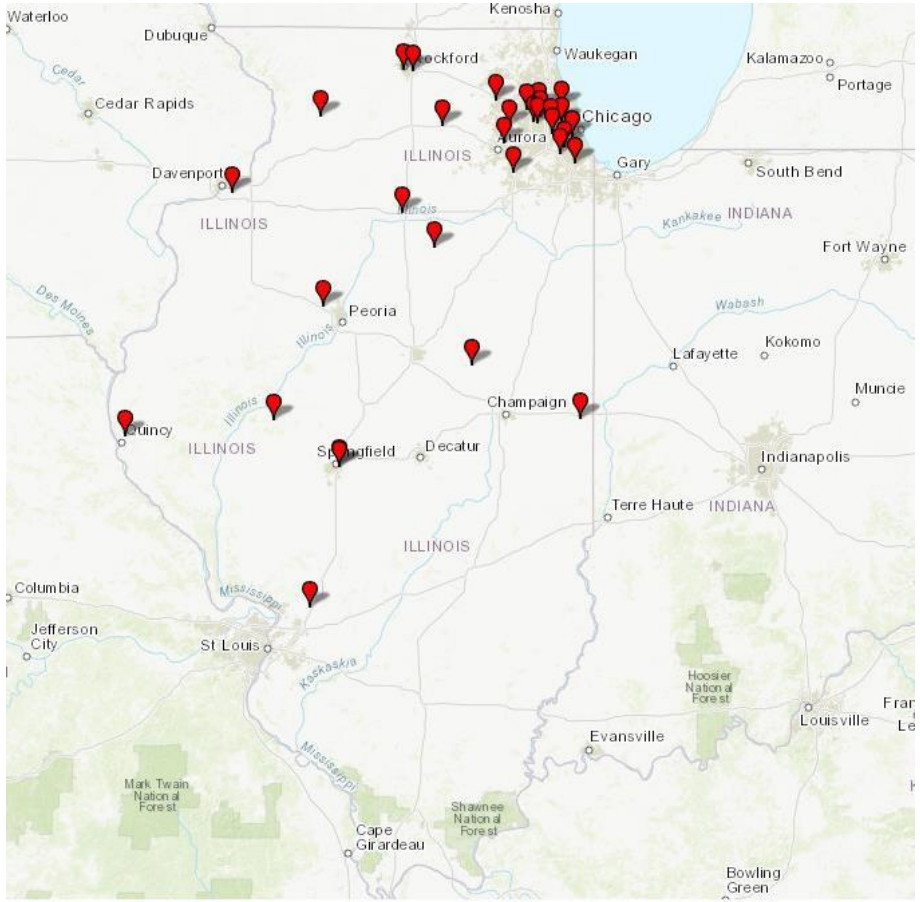

CENTER FOR AUTOMOTIVE RESEARCH



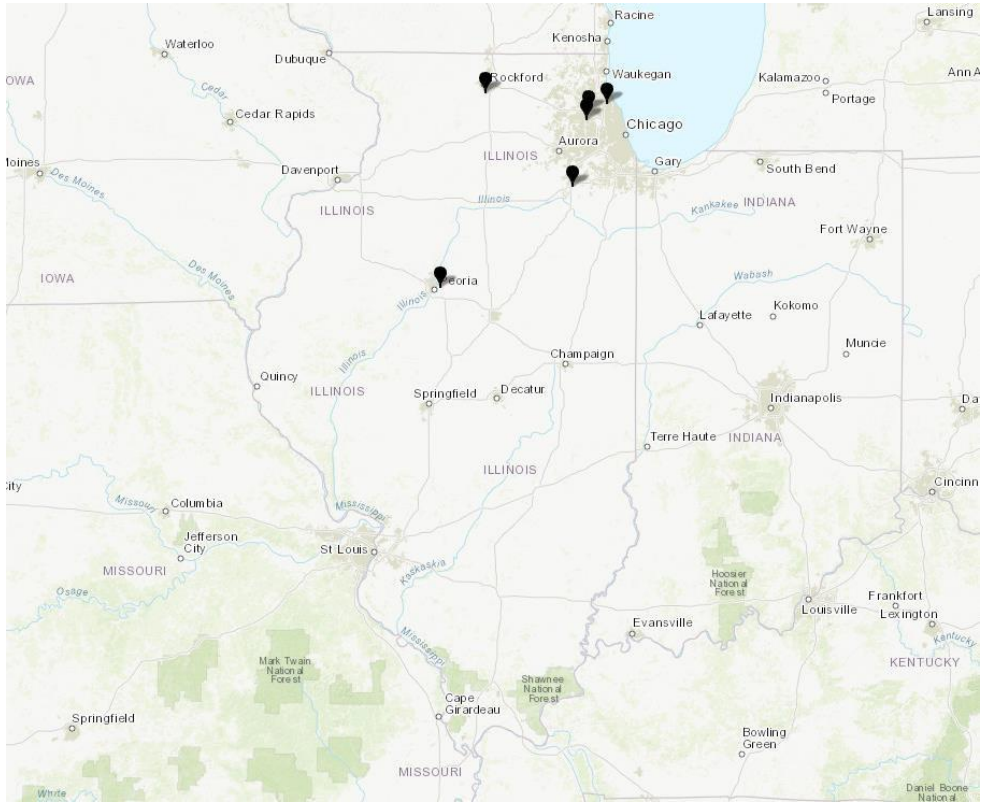
*Source: Center for Automotive Research*

# Illinois Automotive and Related Industries Locations – Aftermarket Product; and Climate Control Systems

*Aftermarket Product*




*Climate Control Systems*

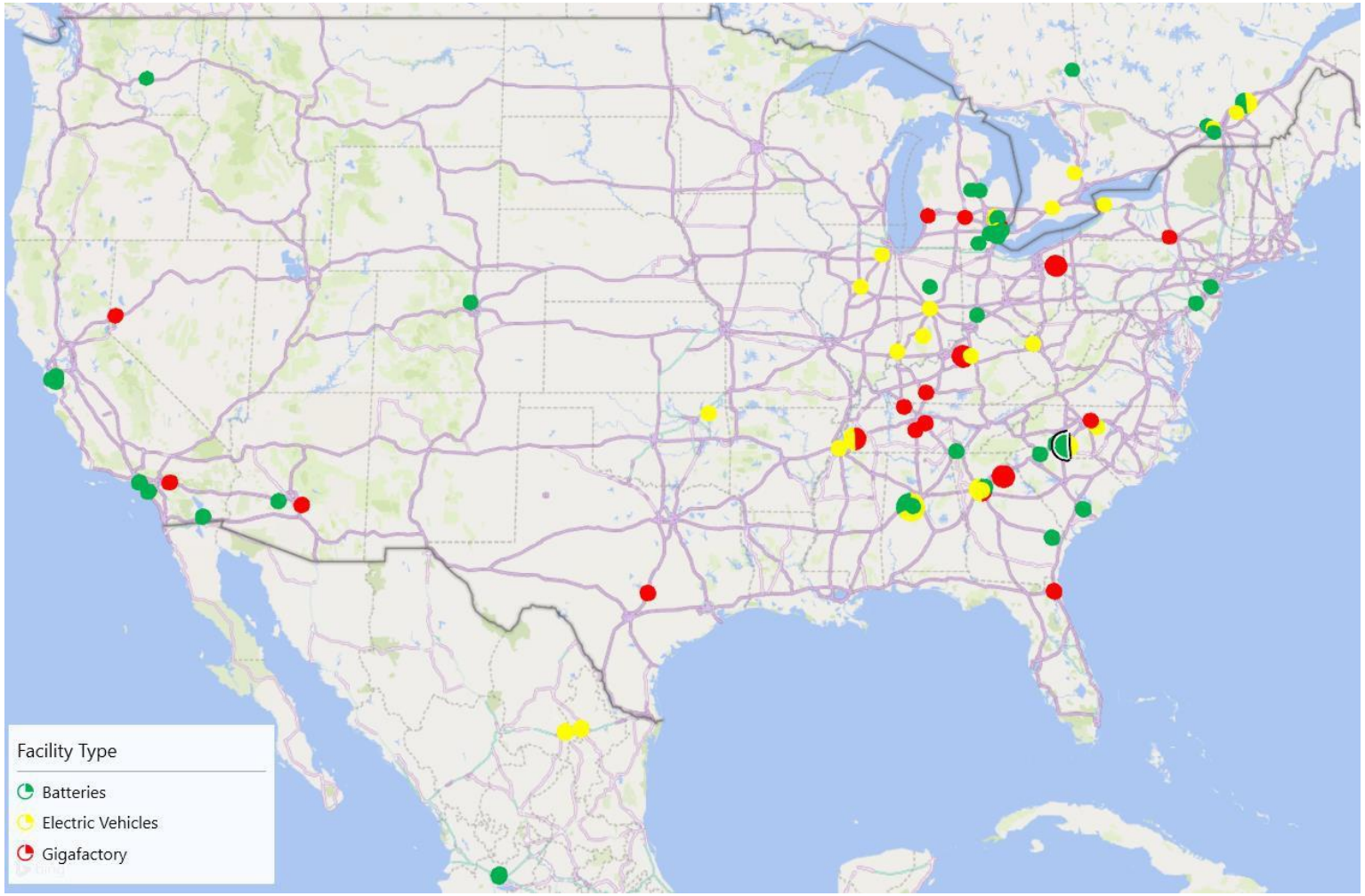



CENTER FOR AUTOMOTIVE RESEARCH



*Source: Center for Automotive Research*

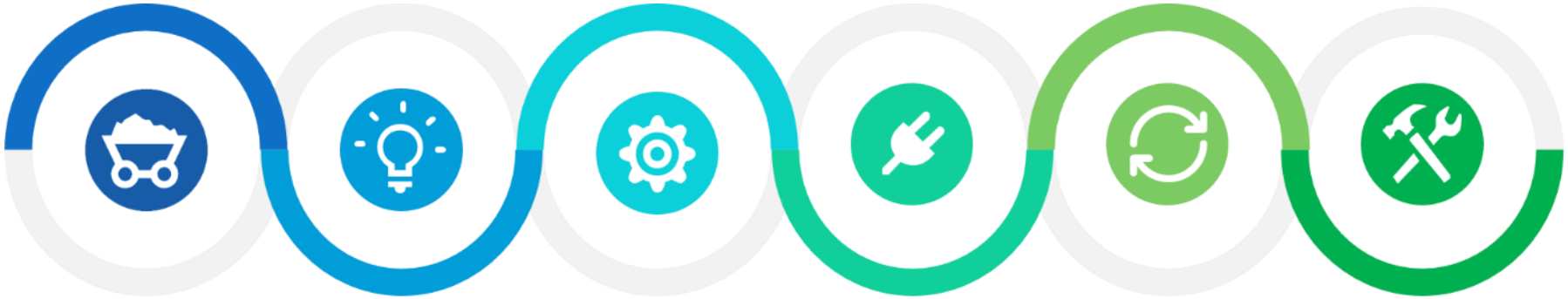
# Locations of NA Electrification Announcements




CENTER FOR AUTOMOTIVE RESEARCH

*Source: Center for Automotive Research*

# Opportunities in the Battery-Electric Vehicle Value Chain



### Mining, Refining, & Processing

**Refining & processing can take place anywhere—regardless of point of extraction**

### R&D, Design, & Engineering

Tied to corporate R&D hubs, national laboratories, & universities

### Production

Broad range of parts, components, & vehicles need to be produced—manufacturing skills augment

### Charging Network & Grid

**Chargers need to be manufactured, planned, deployed, maintained, & repaired**

### Recycling

**End-of-life, mineral reclamation, & conversion for stationary uses—a whole new industry**

### Repair & Maintenance

Service technicians & others who encounter EVs (e.g. first responders) need training

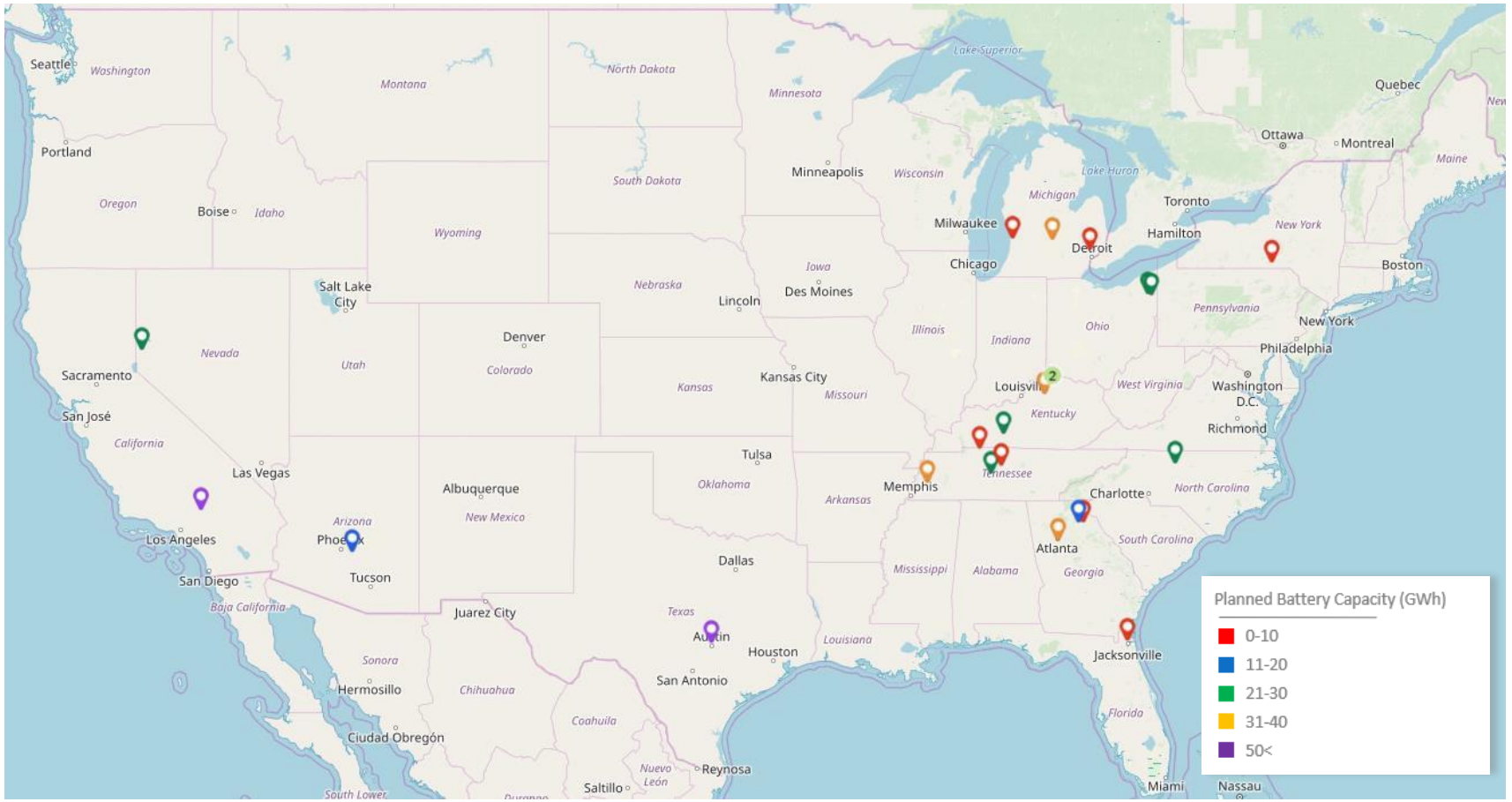
# Major Battery Minerals, U.S. Import Dependence, & Top Sources

- Illinois ranks 25th in the total value of non-fuel mineral production, with leading products including Portland cement, lime, industrial and construction sand and gravel, and crushed stone. Of the nearby midwestern states:
- Michigan has nickel, copper, cobalt, and gold deposits;
- Missouri has lead, zinc, copper, silver, and historic mine tailings that produce nickel, copper, and cobalt; and
- Minnesota has the most significant identified cobalt resources in the United States but does not currently produce cobalt.

| Mineral | 2020 U.S. Import Dependence | Top Import Sources | Top Domestic Sources | Recycling |
|---|---|---|---|---|
| Aluminum | 49% | Canada-50%, UAE-10%, Russia-9%, China-5%, and other-26% | Smelters: Indiana, Kentucky, Missouri, Montana, Texas, New York, Ohio, South Carolina, Washington, West Virginia<br>Alumina refineries: Louisiana | Recycled aluminum is roughly 53% from new (manufacturing) scrap and 47% from old scrap (discarded aluminum products); recycled aluminum from old scrap = 51% of consumption |
| Cobalt | 76% | Norway-20%, Canada-14%, Japan-13%, Finland-10%, other- 43% | Michigan (cobalt-bearing nickel concentrate), and Missouri (nickel-copper-cobalt concentrate) | Cobalt in purchased scrap = 29% of consumption |
| Copper | 37% | Refined copper (85% of non-manufactured imports): Chile-59%, Canada-24%, Mexico-11%, and other-6%. | Arizona (74%), Utah, New Mexico, Nevada, Montana, Michigan, and Missouri | Copper recovered from scrap = 38% of consumption |
| Graphite | 100% | China-33%, Mexico-23%, Canada-17%, India-9%, other- 18% | None, but companies in Alabama and Alaska are developing mines | Information not available |
| Lithium | >50% | Argentina-55%, Chile-36%, China-5%, Russia-2%, other-2% | Operational: Nevada (brine) In development: Arkansas (brine), California (brine), Nevada (clay), North Carolina (ore) | U.S. firm Retriev was the first in North America to recycle lithium metal and lithium-ion batteries in British Columbia and Lancaster, Ohio. Seven companies have or plan to open recycling U.S. operations. |
| Manganese | 100% | Ore: Gabon-69%, South Africa-17%, Mexico-8%, Australia-4%, other-2% | The United States has not produced Manganese ore since 1970. | Manganese reclamation is incidental as part of ferrous and nonferrous metals recycling. |
| Nickel | 50% | Canada-42%, Norway-10%, Finland-9%, Russia-8%, other- 31% | Michigan (cobalt-bearing nickel concentrate), Missouri (nickel-copper-cobalt concentrate), Montana (byproduct of smelting and refining platinum). | Recycled nickel=50% of consumption. |

# Announced NA Battery Production Capacity

## (battery cell production)

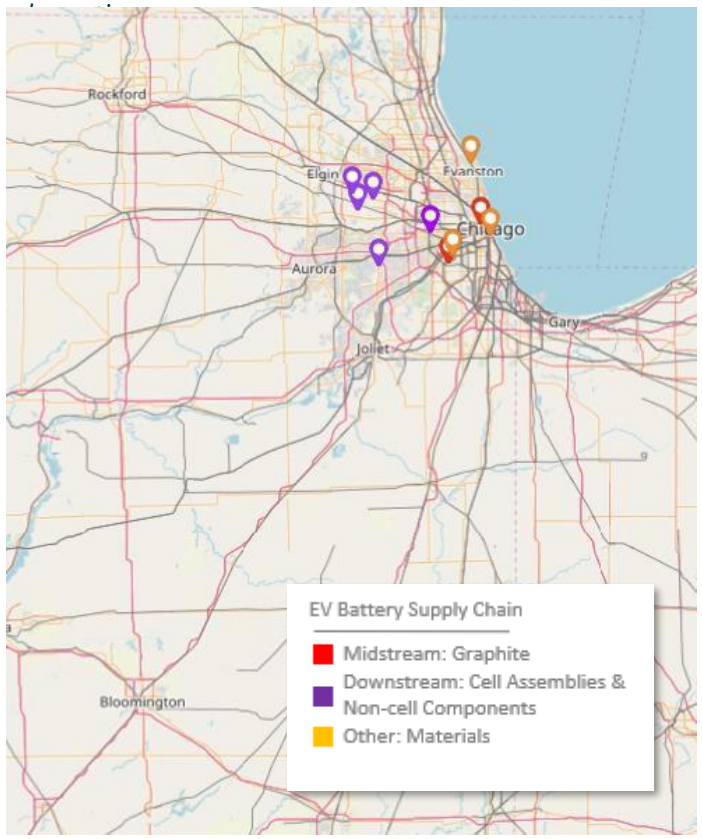



CENTER FOR AUTOMOTIVE RESEARCH

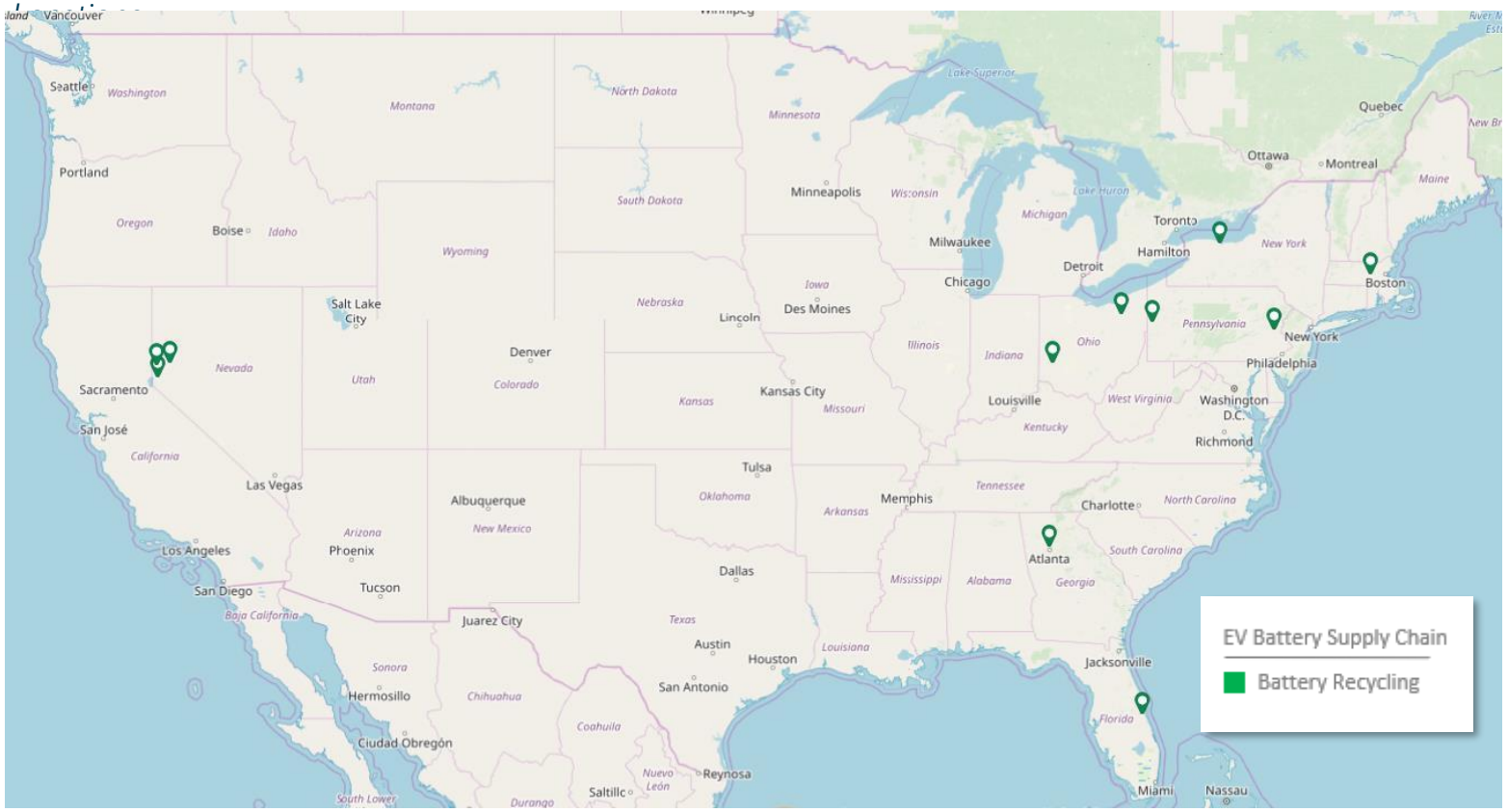
*Source: Center for Automotive Research*

# Battery Supply Chain Locations

*Illinois Battery Supply Chain*




*US Battery Recycling*




CAR CENTER FOR AUTOMOTIVE RESEARCH

*Source: Argonne National Laboratory*

# Definition of Automotive and Related Industries

## Automotive Parts Categories and Sub-Categories

- Aftermarket
  - Retrofitting
  - Modification
  - Special equipment
  - Customization
  - Mechanical services
- Axle/Brake/Body Control
  - Air Brake
  - Axle
  - Brake
  - Sub Brake
  - Vehicle Dynamic Control System

# Definition of Automotive and Related Industries

## Automotive Parts Categories and Sub-Categories

- Body and Exterior
  - Body Panel
  - Frame
  - Body Reinforcement/prote ctor
  - Front/Rear End Module
  - Bumper
  - Door
  - Hood
  - Trunk Lid
  - Window Glass
  - Wiper
  - Window Washer
- Exterior
- Lamp
- Outside Mirror
- Sunroof
- Fuel Tank
- Weather Strip
- Gas Spring
- Horn
- Key Set
- Clean Energy System
  - Battery/Capacitor (Electric Vehicle/Hybrid Vehicle/Fuel Cell Vehicle)
  - Drivetrain system (Electric Vehicle/Hybrid Vehicle/Fuel Cell Vehicle)
  - Fuel cell system
  - Power control system (Electric Vehicle/Hybrid Vehicle/Fuel Cell Vehicle)

# Definition of Automotive and Related Industries

## Automotive Parts Categories and Sub-Categories

- Climate Control
  - HVAC Module
  - Heater
  - Auxiliary Heater
  - Preheater
  - Ventilator
  - Air Conditioner
- Drivetrain
  - 4WD Transfer
  - Automatic Transmission
  - Clutch
  - CVT
  - Differential
  - Drivetrain Parts
  - LSD
  - Power Take Off
  - Transmission

# Definition of Automotive and Related Industries

## Automotive Parts Categories and Sub-Categories

- Driving Support and Telematics
  - Advanced Driver Assistance System,(ADAS)
  - Telematics
  - Entertainment
  - Security System
- Electronics/Electric Parts
  - Actuator
  - Electric Cable
  - Electric Connector
  - Electronics Parts
  - Hidden switch
  - Motor
  - Relay
  - Semiconductor
  - Sensor
  - Wire Harness

# Definition of Automotive and Related Industries

## Automotive Parts Categories and Sub-Categories

- Engine and Engine Parts
  - Engine Structure
  - Air/Fuel Management
  - Gasoline Fuel Injection System
  - Diesel Injection System
  - Other Fuel Systems
  - Fuel Handling And Evapo System
  - Exhaust System
  - Valvetrain
- Ignition System
- Turbo/Supercharger
- Engine Lubricating System
- Engine Cooling System
- Engine Electric System
- Engine Control System
- Engineering Service
  - Design and drafting service
  - Engineering service

# Definition of Automotive and Related Industries

## Automotive Parts Categories and Sub-Categories

- Interior
  - Cockpit Module
  - Instrument Panel
  - Airbag System
  - Steering Wheel
  - Seat
  - Seat Belt
  - Interior Trim
  - Instrument Switch
- Metalworking, Stamping, Machining, Molding
  - Metal forming
  - Stamping
  - Hydroforming
  - Machining
  - Casting
  - Die casting
  - Forging
  - Sintering
  - Aluminum extruded parts
  - Roll forming
  - Welding
- Plastic molding
- Rubber parts
- Surface treatment/Heat treatment

Various material processes

# Definition of Automotive and Related Industries

## Automotive Parts Categories and Sub-Categories

- Motor Vehicle Assembly and Motor Vehicle Manufacturing Equipment
  - Original equipment manufacturing
  - Contract manufacturing
  - General assembly
  - Sub assembly
- Research and Development

# Definition of Automotive and Related Industries

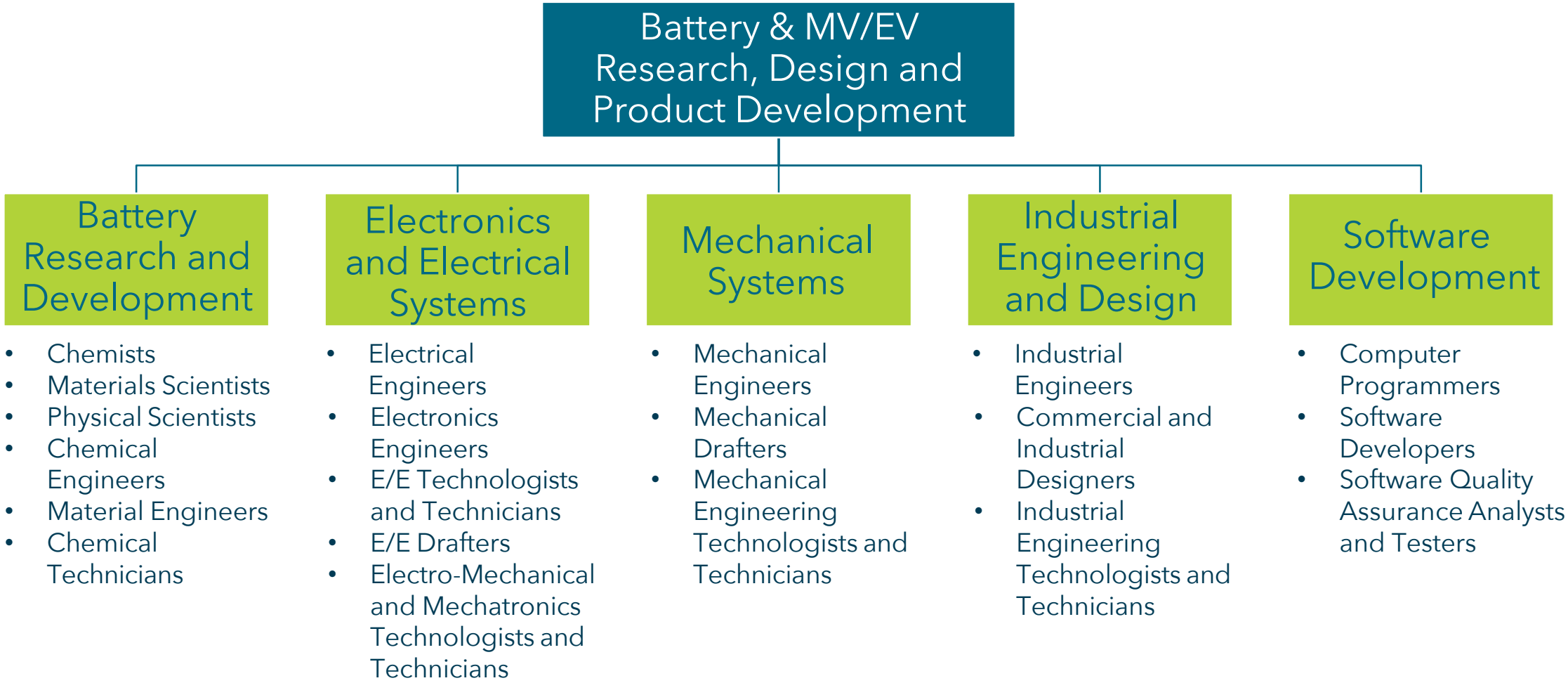
## Automotive Parts Categories and Sub-Categories

- Small and General Parts
  - Fastener / Connector
  - Component Parts
  - Pipe / Hose
  - Bush / Seal
  - Adhesive / Tape
  - Fabric
  - General Commodity
- Suspension and Steering
  - Chassis Module
  - Steering
  - Suspension
  - Air Suspension
  - Electric Suspension
  - Suspension Control
  - Shock Absorber
  - Road Wheel
  - Tire

# Deliverables and Proposed Deadlines:

- Automotive Electrification Presentation
  - May or June 2022
- Illinois Automotive Manufacturing Base Study (delivered in slide presentation format)
  - Initial Draft: June 2022
  - Final Draft: June 2022
  - Study Results Presentation: July 2022

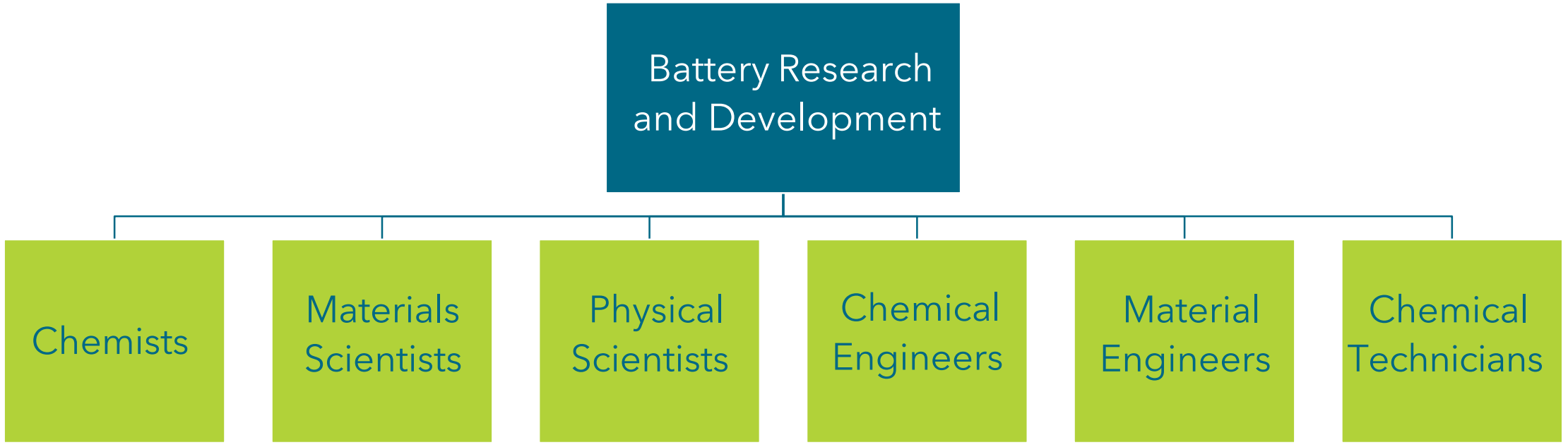
# Occupations for Motor Vehicle, Battery, and Electric Vehicle Research, Design, and Product Development





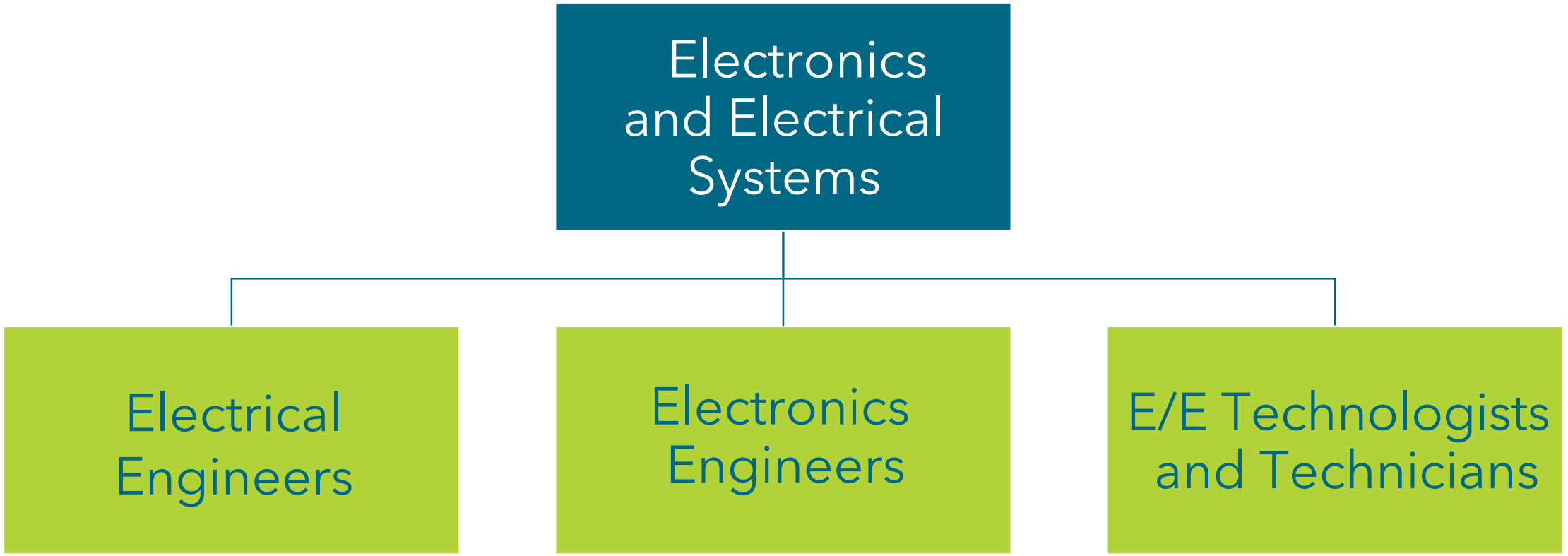

*Source: CAR Analysis*

# Occupations for Battery Research and Development in Illinois



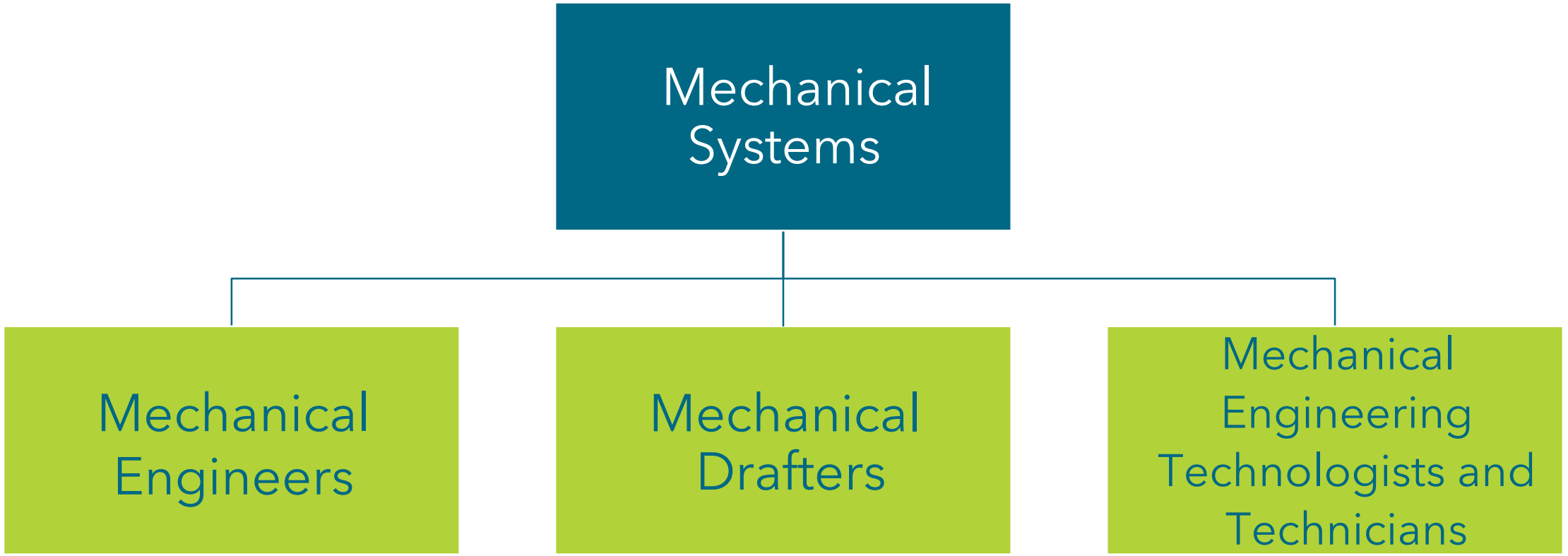

*Source: CAR Analysis*

# Occupations for Electronics and Electrical Systems



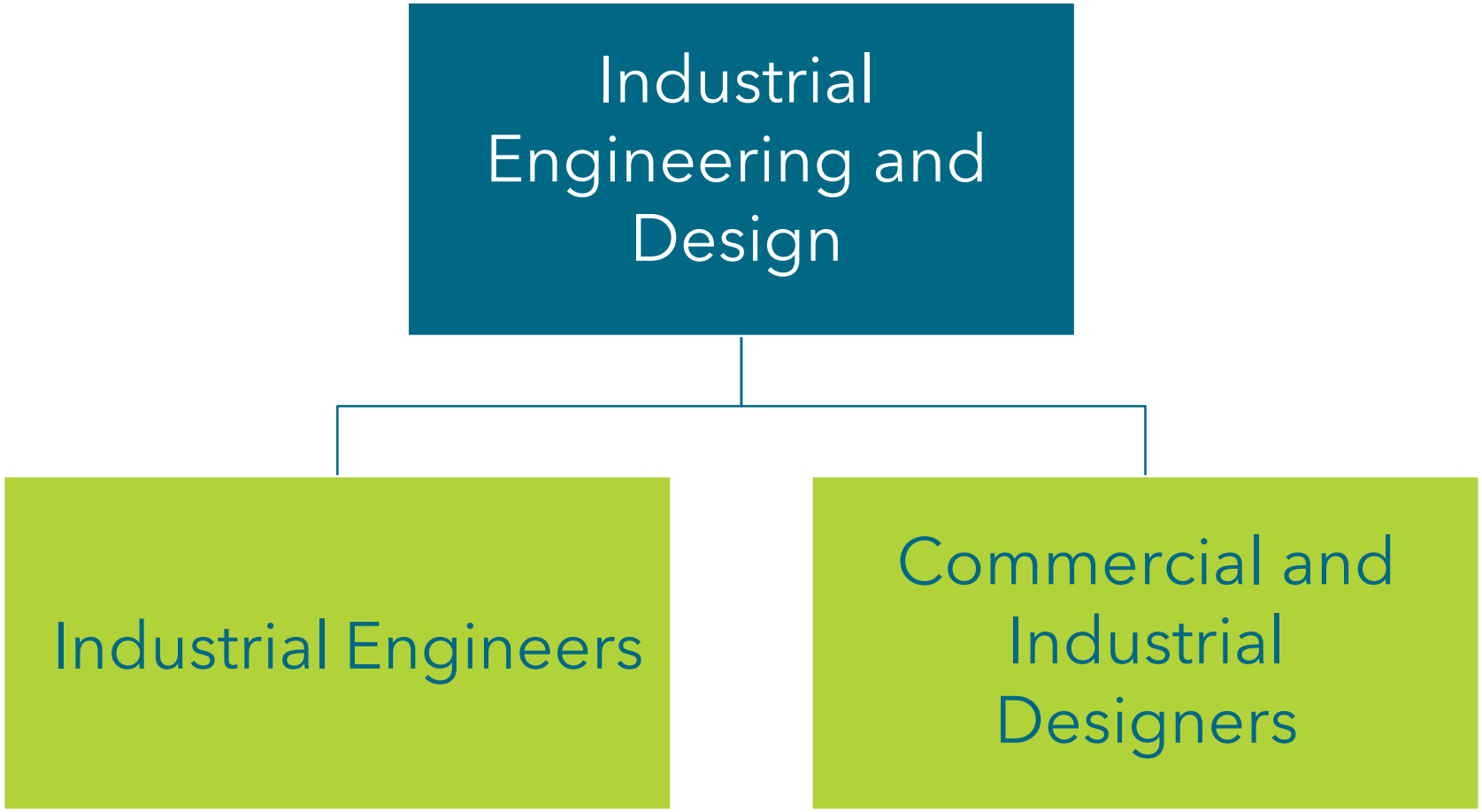

*Source: CAR Analysis*

# Occupations for Mechanical Systems



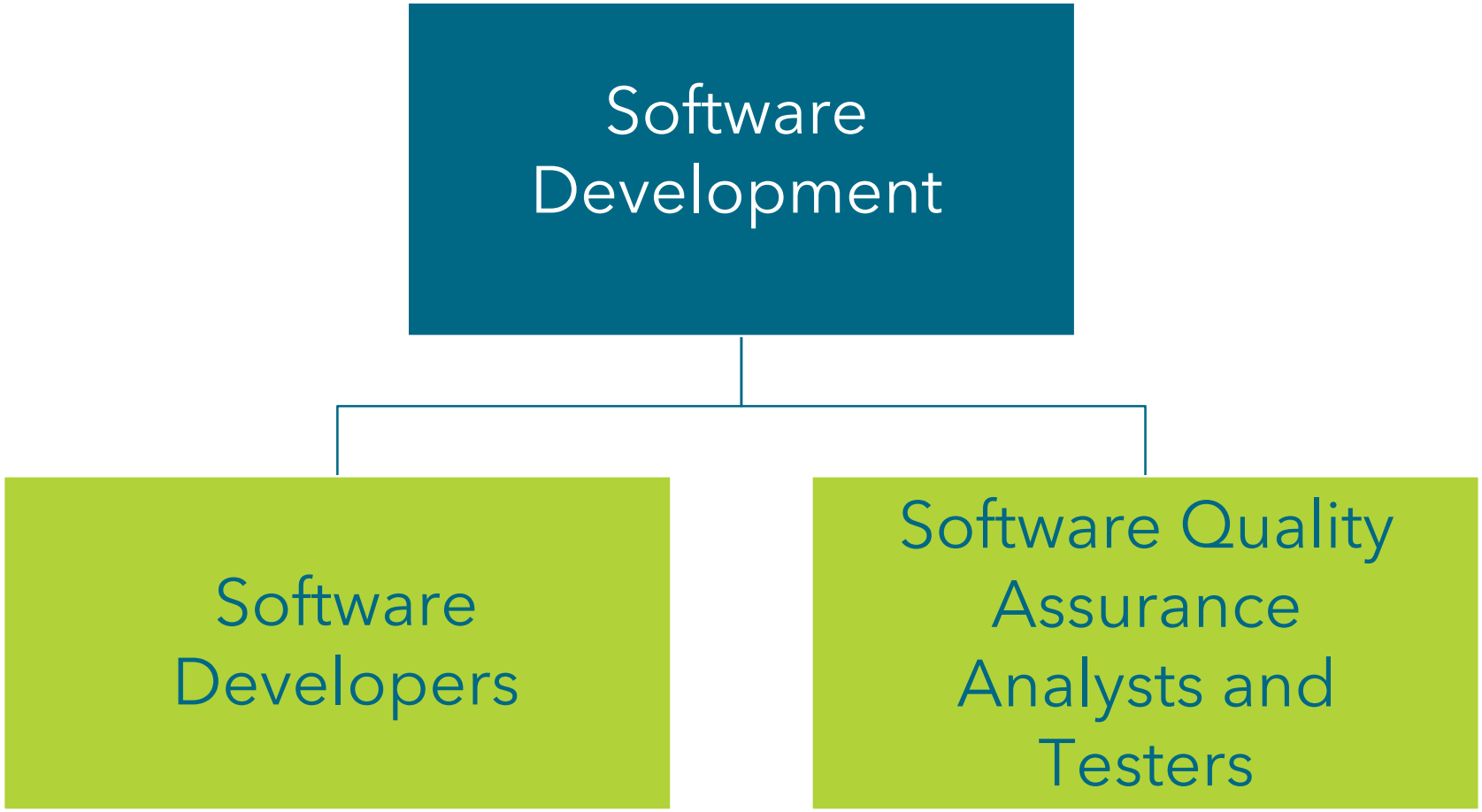

*Source: CAR Analysis*

# Occupations for Industrial Engineering and Design




*Source: CAR Analysis*

# Occupations for Software Development




*Source: CAR Analysis*

# About Illinois Manufacturing Excellence Center (IMEC)

## Contact IMEC

1501 W. Bradley Avenue
Peoria, IL 61625

- Phone: 888-806-4632
- Email: info@imec.org
- Website: https://www.imec.org/

IMEC is a team of improvement specialists and technicians dedicated to providing organizations in Illinois with the tools and techniques to create sustainable competitive futures. The experienced hands-on team at IMEC works closely with its clients to plan critical business improvements in the areas of **Leadership, Strategy, Customer Engagement, Operations, and Workforce.**

### Core Purpose

Fostering long-term economic and workforce competitiveness

### Mission

Committed to driving growth through enterprise excellence

### Vision

Igniting Illinois manufacturing excellence and global competitiveness.

# About Illinois Manufacturers' Association (IMA)

## Contact IMA

**IMA Headquarters**
1301 W. 22nd Street, Suite 307
Oak Brook, Illinois 60523

(630) 368-5300
(800) 875-4462
Fax: (630) 218-7467

**Springfield Office**
220 East Adams
Springfield, IL 62701

(217) 522-1240
(800) 875-4462
Fax: (217) 525-0055

Website: https://ima-net.org/

Manufacturing matters in Illinois! For more than two hundred years, innovative and ingenious Illinois manufacturers have made the world a better place to live by creating life-saving products, building our infrastructure, transporting people and products around the globe and into space, feeding the world, powering our homes and businesses, developing pioneering technology and communication, and providing for our nation's defense.

The Illinois Manufacturers' Association is marching forward, side-by-side with industry to address challenges and shape the future. A powerful and respected leader from the White House to the Governor's Office, Congress to the General Assembly, and City Halls across the state, the IMA is the unifying voice and champion of manufacturing in Illinois.

ILLINOIS MANUFACTURERS' ASSOCIATION