Electric Vehicle Product Commission Tasking Report

Opportunities for the Hoosier Automotive Supply Chain and Talent

September 30, 2022

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About the EVP Commission

About the EVP Commission

Governor Holcomb signed House Bill 1168 into law during the 2021 legislative session, establishing the Electric Vehicle Product (EVP) Commission. The 10-member commission is comprised of legislative representatives and industry leaders who are tasked with:

- Evaluating the inventory of existing electric vehicle product facilities and production capability.
- Evaluating the inventory of skilled and nonskilled workers in the electric vehicle product industry.
- Evaluating opportunities and needs for training within the electric vehicle product industry.
- Determining if training centers promoting careers in the electric vehicle product industry should be created or transitioned from traditional automotive industry training centers.
- Identifying existing manufacturing competencies within the traditional automotive industry and determine how the existing competencies could be leveraged to increase the production of electric vehicles.
- Identifying and evaluating opportunities for growth within the electric vehicle product industry.
- Identifying and documenting results from previous instances of retooling and transforming manufacturing facilities in the automotive industry.
- Identifying opportunities for research and development within the electric vehicle product industry.

Members Of The Commission

The EVP Commission members are as follows:

- David Dukes, Stellantis
- Mike Maten, GM
- Danny Ernstes, UAW
- Paul Mitchell, Energy Systems Network
- Ben Wrightsman, Battery Innovation Center
- Craig Kelle, Toyota
- Rep. Mike Karickhoff, State Representative
- Rep. Carey Hamilton, State Representative
- Sen. J.D. Ford, State Senator
- Sen. Jim Buck, State Senator

Introduction

Indiana has been a center of automotive manufacturing for 125+ years, which includes a deep history in automotive manufacturing technologies, capabilities, and innovation. While internal combustion engines (ICE) have fueled many products, early electric vehicles (EVs) played a part in technological breakthroughs, and today it is leading the charge for innovations into tomorrow. It is prime time for Indiana to sharpen its focus on technology and development in this advanced automotive sector. In this initial report, the EVP Commission will look at how existing capabilities are being leveraged, what opportunities exist to further apply the state's legacy know-how, and where to apply known innovative and creative aptitude. Through this understanding, the EVP Commission can influence the next generation of automotive manufacturing with the inclusion of electrification supported by our well-established ICE heritage. The challenge is transforming, retraining, retooling, and repurposing workforce and facilities, while also ensuring innovation, development, sustainment, and attraction is brought to the forefront. Indiana has every capability to continue to be a leader in the automotive manufacturing sector, and through the work of those in the state, it can solidify itself as a key stakeholder in this next generation of electric vehicle product manufacturing.

This document is designed to address eight primary tasks put forward by the Electric Vehicle Product (EVP) Commission and is meant to be read as independent chapters. With the rapid development of EV product manufacturing opportunities that arise frequently in this era, it is important to note that all data and information is only a snapshot of the environment at one point in time. Because of this rapid development, this is a living document intended to be updated on a regular basis by the EVP Commission and associated team members.

Impact

The map and chart below highlight recent confirmed investments since 2021 related to EV production and set the foundation for future relocation and expansion projects throughout the State of Indiana. These investments are current as of September 30, 2022.

Investment Locations

Company	Investment	Location
GM	$51,000,000	Bedford, Indiana
GM	$2,000,000,000	New Carlisle, Indiana
GM	$491,000,000	Marion, Indiana
Honda	$54,600,000	Greensburg, Indiana
Stellantis and Samsung SDI JV	$229,000,000	Kokomo, Indiana
Stellantis and Samsung SDI JV	$2,500,000,000	Kokomo, Indiana
Toyota	$803,000,000	Princeton, Indiana
TOTAL	**$10,474,000,000**	

Source: EVP Commission

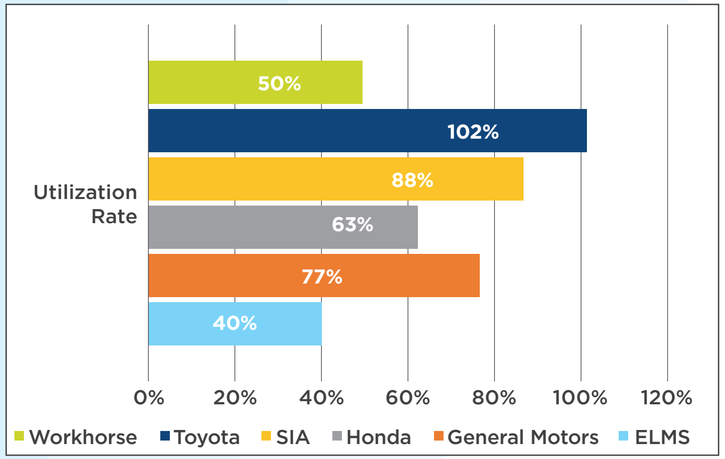
Evaluate the inventory of existing electric vehicle product facilities and production capability.

Task 1

Evaluate the inventory of existing electric vehicle product facilities and production capability.

The automotive industry is in the midst of a transition - replacing the internal combustion engine (ICE)-based cars with a new energy source – battery-powered electric vehicles (EV). Based on research from Purdue University, the possible U.S. market size for EVs goes from 1.45 million to 6 million vehicles by 2030[1], a significant opportunity, albeit highly variable, and a function of automaker choices. This shift from ICE to EV is forecasted to have a corresponding decrease in the volume of ICE and impact the automotive industry supply chain.

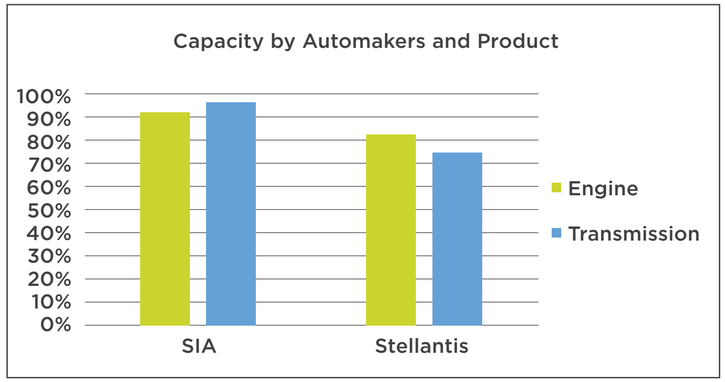
Indiana Motor Vehicle Production Forecast and Capacity



Source: LMC Automotive, S&P Global Connect, CAR Research

According to research gathered by the Indiana Economic Development Corporation, a few motor vehicle production facilities have capacity for existing production projections. ELMS and Workhorse have the most capacity to date, respectively, likely based on recent location and expansion plans.

Indiana Powertrain Production Forecast and Capacity



Source: LMC Automotive, S&P Global Connect, CAR Research

Based on research from LMC Auto, S&P Global Connect, and CAR Research, the facilities' capacity for additional production of ICE engines and transmissions is limited. Therefore, the State of Indiana has a unique opportunity to bolster the expansion for additional production capabilities.

Supply Chain Disruption Summary

22,132

Total Manufacturing Companies in Indiana

8,053

Total Automotive Companies in Indiana

3,548

Other Automotive Companies[2]

769

Total Unique ICE Companies

201

Total Unique EV Companies

3,535

Total ICE & EV Combined Companies

Source: EVP Commission

[1] https://www.iea.org/reports/global-ev-outlook-2019

[2] *Other Automotive Companies are other manufacturers not related to Unique ICE and/or Unique EV Companies*

Indiana EV Battery Assembly and Reuse

Battery Manufacturing/Production

Anderson: EnerDel

Anderson: Altairnano

Indianapolis: EnPower

Kokomo: Stellantis and Samsung SDI JV

Newberry: Battery Innovation Center

Indiana: INoBat and Ideanomics (location TBD)

Battery Recycling

Indianapolis: Cirba Solutions (The Heritage Group)

Fishers: ReElement

Greenfield: Eclipse Energy

Information current as of September 30, 2022

Indiana Lithium-Ion Battery Supply Chain (company, industry, product, and workforce)

Using data collected from the NAATBatt North American Lithium-Ion Battery Supply Chain Database[1], the supply chain segments include:

Manufacturing Supply Chain

- Raw Materials
- Battery Grade Materials
- Other Battery Components

Materials

- Electrode and Cell Manufacturing
- Module/Pack Manufacturing
- EOL Supply Chain
- Other Segment Supply Chains
- Equipment
- Service
- R&D
- Modeling and Software
- Distributors

The current evaluation of Indiana's Lithium-Ion Battery supply chain indicates a ripe opportunity for attracting more suppliers within the greater EV production supply chain.

[1] https://www.nrel.gov/transportation/li-ion-battery-supply-chain-database-download.html

Company	Industry	Product	Workforce
Unifrax	Battery grade materials	Silicon composites	150
EnPower, Inc.	Cells and Electrodes	NMC	117
Altair Nanotechnologies	Cells and Electrodes	LTO	106
Stellantis- Samsung SDI	Cells and Electrodes	Battery	1400
Parker LORD	Modules and Packs	Thermal Systems	N/A
Alion	Modules and Packs	Modules/arrays	N/A
Exponential Power	Modules and Packs	Packs	100
Morgan Advanced Materials	Modules and Packs	Thermal Systems	N/A
Battery Innovation Center	Services		28
Eclipse Energy LLC	Services		4
ReElement Technologies	Material supplier	Rare earth elements	N/A

Source: https://www.nrel.gov/transportation/li-ion-battery-supply-chain-database-download.html

As EV demand rises, it is particularly important for manufacturers to manage the procurement and production of batteries. According to research from from Ultima Media and ABB, leaders are critically investigating whether global supply chains will be able to keep up with demand across the battery supply chain. Based on a March 2021 report:

"Even before the Covid-19 impact, there were growing reports of OEMs facing production challenges as a result of difficulties sourcing batteries and cells. In the aftermath of global shutdowns and subsequent restarts, EV production again felt the squeeze in supply as demand ramped up. More recently, the wider shortage of electronic components, including semiconductors and microchips, has compounded these issues. There are further bottlenecks in the supply of lithium and certain materials and minerals in the battery supply chain, with the risk of price spikes. Such supply issues could lead to potential lost sales, unnecessary costs, and lower profits for manufacturers at a particularly critical time.

Analysis reveals why many of these problems arise. Not only are there a new set of companies compared to the supply chain for ICE, but the EV battery supply chain introduces new technologies, regulations, safety, and environmental concerns. But the growth of the sector is set to be exceptional, propelled by 20% compound annual growth rates (CAGR) for global EV sales over the next decade. Battery production capacity will likely need to outpace EV demand to meet the rising need for lithium-ion power in other sectors, along with mitigating supply and production constraints. We estimate that global capacity for lithium-ion batteries will increase from 450-gigawatt hours (GWh) in 2020 to more than 2,850 GWh by 2030."[1]

Furthermore, it will be important for the EVP Commission to evaluate the current automotive manufacturing supply chain purchases to identify the ripple effect of EVs. The chart below showcases the current buyer purchases for the automotive manufacturing industry to date.

[1]*Source: Electric Vehicle Supply Chain Analysis, March 2021, page 7*

The chart below highlights the Indiana automotive manufacturing supply chain and provides details on purchases from suppliers located in Indiana (i.e. In-Region) and outside of Indiana (i.e. Out-of-Region). The data indicates opportunities to attract or develop suppliers within this automotive supply chain.

Supplier Industries	Purchases from In-Region Firms	Purchases from Out-of-Region Firms	Total Supplier Employ In-Region	Supplier Location Quotient (In-Region)	% In-Region Purchase
Motor Vehicle Seating and Interior Trim Manufacturing	$913,016,000	$0	9,713	6.59	**100%**
Motor Vehicle Metal Stamping	$516,924,000	$342,734,000	4,048	2.45	**60%**
Other Motor Vehicle Parts Manufacturing	$757,002,000	$0	12,385	4.07	**100%**
Motor Vehicle Transmission and Power Train Parts Manufacturing	$724,368,000	$0	21,069	13.15	**100%**
Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	$435,571,000	$261,944,000	2,103	1.80	**62%**
Iron and Steel Mills and Ferroalloy Manufacturing	$245,794,000	$0	16,809	10.03	**100%**
Motor Vehicle Body Manufacturing	$189,686,000	$15,915,000	3,846	3.49	**92%**
All Other Plastics Product Manufacturing	$204,644,000	$0	20,870	3.23	**100%**
Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	$191,549,000	$0	3,083	4.69	**100%**
Machine Shops	$114,754,000	$46,196,000	10,560	1.88	**71%**

Source: JobsEQ. Data as of 2022 Q1.

Supplier Industries	Purchases from In-Region Firms	Purchases from Out-of-Region Firms	Total Supplier Employ In-Region	Supplier Location Quotient (In-Region)	% In-Region Purchase
Other Engine Equipment Manufacturing	$158,422,000	$0	10,603	11.28	**100%**
Motor Vehicle Electrical and Electronic Equipment Manufacturing	$145,518,000	$0	3,666	3.06	**100%**
Motor Vehicle Brake System Manufacturing	$133,933,000	$0	1,886	4.33	**100%**
Audio and Video Equipment Manufacturing	$11,124,000	$116,299,000	111	0.27	**9%**
Semiconductor and Related Device Manufacturing	$668,000	$114,968,000	68	0.02	**1%**
Glass Product Manufacturing Made of Purchased Glass	$92,105,000	$0	2,489	2.65	**100%**
Metal Crown, Closure, and Other Metal Stamping (except Automotive)	$69,890,000	$17,539,000	2,532	2.41	**80%**
Nonferrous Metal Die-Casting Foundries	$46,201,000	$0	2,216	4.76	**100%**

Source: JobsEQ. Data as of 2022 Q1.

Evaluate the inventory of skilled and nonskilled workers in the electric vehicle product industry.

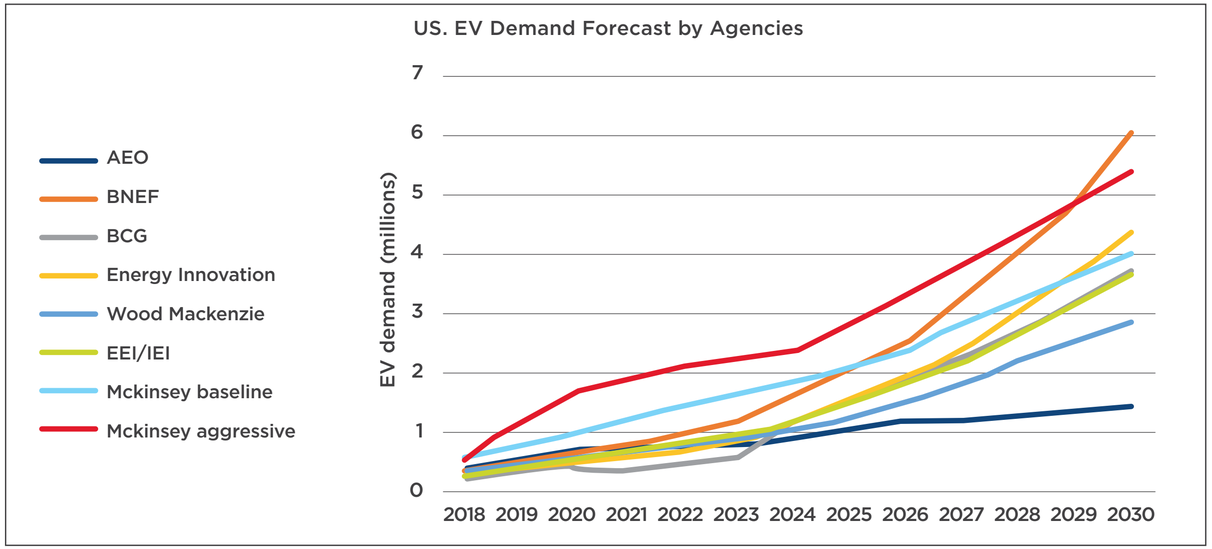
Task 2

Evaluate the inventory of skilled and non-skilled workers in the electric vehicle product industry.

As the electric vehicle product industry develops in Indiana, workers are a key component in this equation. Purdue University in its report "Manufacturing Pain and Gain? - The EV Options in Indiana and Beyond"[1] suggests that there will be a predicted reduction of labor by 30% if nothing is done to address the shift. For example, if a company produces seats or trim, it would be able to continue production for EVs instead of ICE. However, if engines or exhaust systems are involved, the company would be more vulnerable to impact. The United Auto Workers in its report "Taking the High Road: Strategies For a Fair EV Future"[2] states that EVs could erode employment in engines, transmissions, exhaust systems, and fuel systems. However, in turn, it could create employment opportunities in batteries, electric motors, electronics, thermal systems, braking systems, and semiconductors.

Therefore, the Commission believes that to properly evaluate the current inventory of skilled and non-skilled workers in the electric vehicle product industry it must first gain a perspective of the traditional automotive industry as it exists specific to Indiana. Expanding this evaluation, it provides an opportunity to see who exists in these spaces, what is being manufactured, what are the processes and competencies and to gain an understanding of how manufacturers are transitioning from Internal Combustion Engines (ICE) to the Electrical Vehicle (EV).

The automotive industry is in the midst of a transition - replacing the ICE cars with a new energy source – battery-powered Electric Vehicles (EV). Based on research from the EVP Commission, the possible U.S. market size for EVs goes from 1.45 million to 6 million vehicles by 2030[3], a significant opportunity, albeit highly variable, and a function of automaker choices. This shift from ICE to EV is forecasted to have a corresponding decrease in the volumes of ICE and will impact the automotive industry supply chain.



[1] *Dr. Iyer, A. V., Dunlop, S. R., Dr. McLeod, A., Vasher, R., Thakkar, D. J. (2021). Manufacture: Pain or Gain? – The EV Options in Indiana & Beyond*

[2] *https://uaw.org/wp-content/uploads/2019/07/190416-EV-White-Paper-REVISED-January-2020-Final.pdf*

[3] *Cooper, A. & Schefter, K. (2018). Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030. https://www.edisonfoundation.net/-/media/Files/IEI/publications/IEI_EEI-EV-Forecast-Report_Nov2018.ashx*

See the Methodology in Appendix A.

The Magnitude of the Unique ICE and EV Ecosystem

The diagram below shows Indiana's Unique ICE, combined ICE & EV, and Unique EV statistics. The data showcases the reach of the ICE and EV ecosystem and highlights the number of companies, total employees, Production employees, and Non-Production employees.

The methodology used in the ICE and EV industry analysis is based on North American Industry Classification System (NAICS) codes which utilizes self-reported business classifications by automotive companies. This data is only representative of four NAICS code categories: 31-33, 42, and 44. These statistics are based on the data from Dun & Bradstreet (D&B). The categorization of Automotive companies in Indiana is based on filtering 160 six-digit NAICS codes that are associated with automotive manufacturing. This NAICS code list can be provided by request. The Unique ICE, Unique EV, and Combined ICE & EV statistics are based on the keyword search in the business description data obtained from D&B and LinkedIn.

	Unique ICE	Unique EV	Combined ICE & EV
Companies	769	201	3,535
Employees	40,175	9,816	137,519
Prod. Emp.	36,961	9,031	126,517
Non-Prod. Emp.	3,214	785	11,002

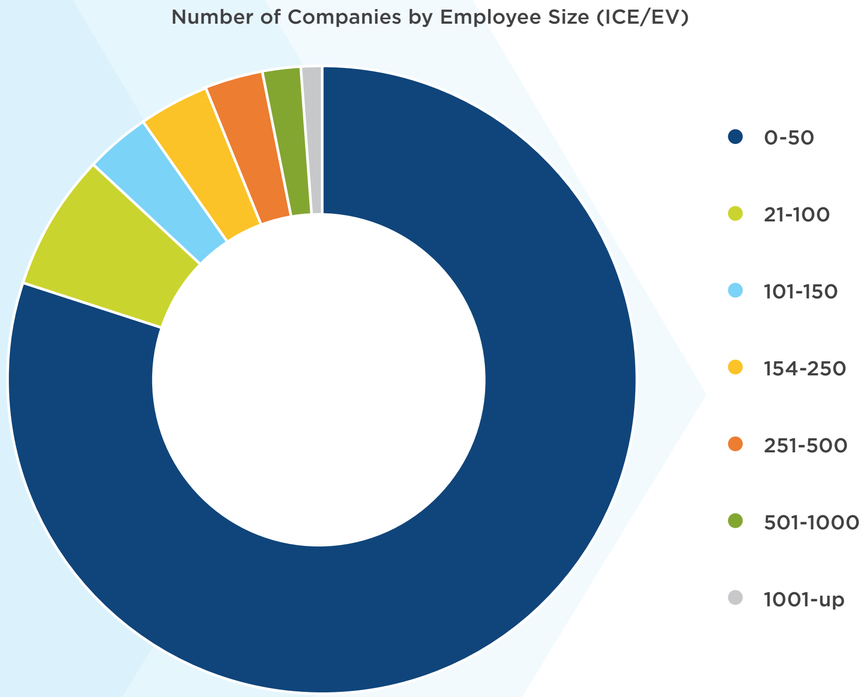
Source: Purdue University

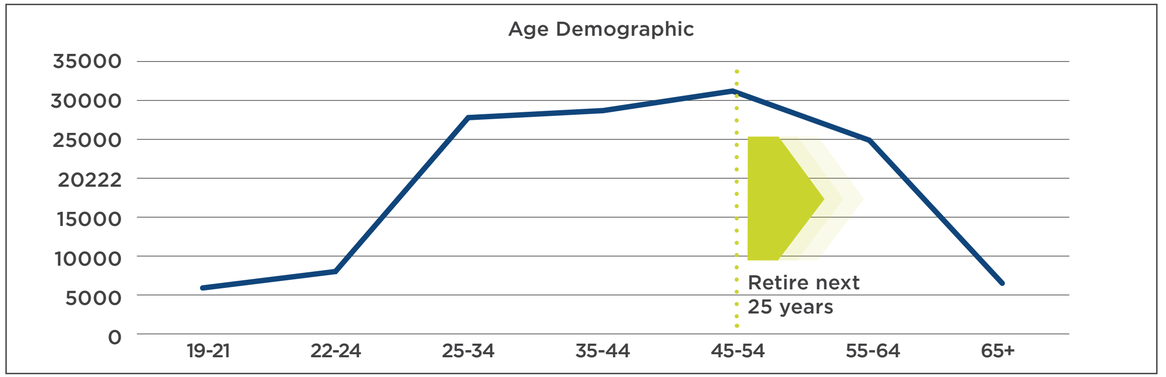
Note: Based on manufacturer guidance, there are 92% production employees and 8% non-production employees.

In summary, the Unique EV category comprises of about 200 companies and 10,000 employees in Indiana. The Unique ICE category is larger, comprising about 770 companies and 40,000 employees in Indiana. Combined, the ICE & EV sector comprises more than 3,500 companies and 137,000 employees in Indiana. It is important to note the significance of employment that will be impacted by the shift from ICE motor vehicle production to EV.

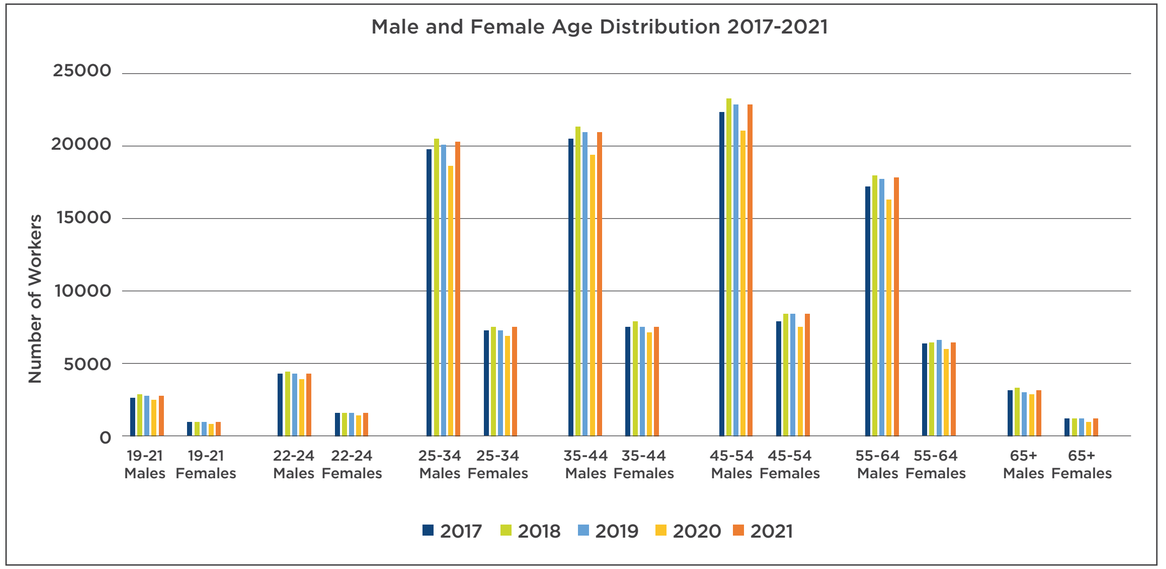
To further validate the impact, the data charts below indicate the magnitude of workers and the potential impact of the disruption. Certainly, the ICE and EV companies with less than 50 employees will potentially be more significantly affected.

In addition to the shift in processes and training that will shock the system of existing ICE employees, data shows the impending change from a workforce heading toward retirement.





Source: Purdue University



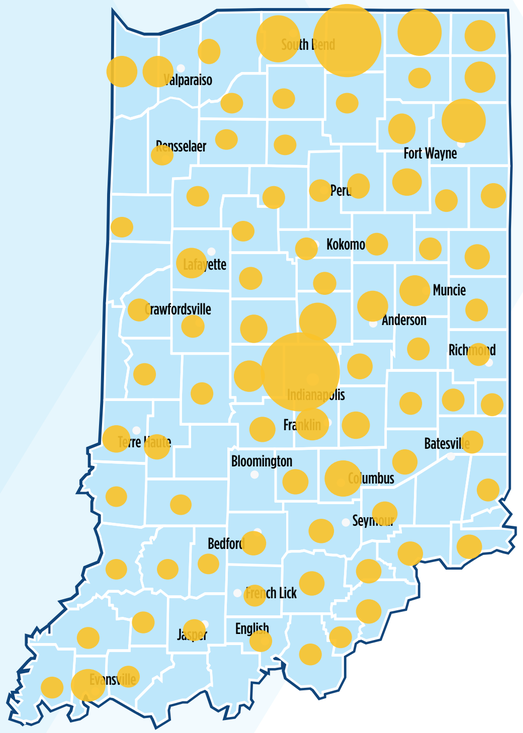
Source: Purdue University

The Footprint of Unique ICE, Unique EV, and Combined Sectors

To visualize the impact of the unique ICE, unique EV, and Combined Sector automotive companies present in Indiana, the maps below showcase the breadth of their footprint.

Unique ICE Companies

The map and table below detail the unique ICE automotive manufacturing companies present in Indiana, and the number of employees working at these companies. The size of the bubbles represents the number of companies in the county.



769

Count of Companies

40,175

Employees

36,961

Production Employees

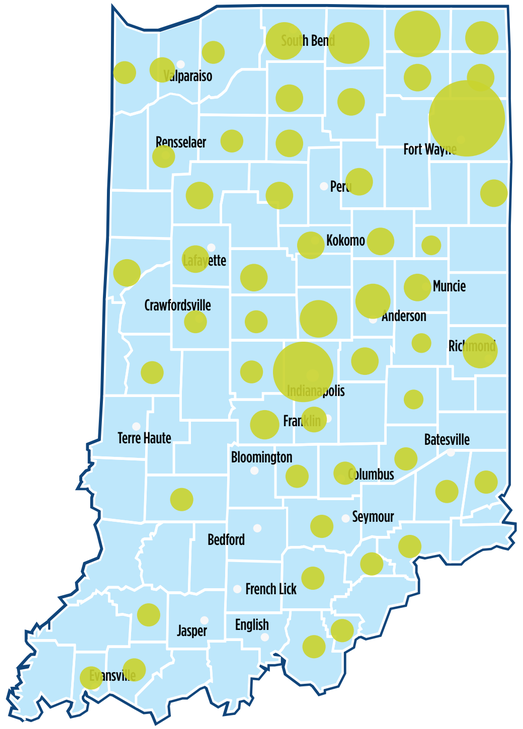
3,214

Non-Production Employees

Note: The Unique ICE companies span over 70 unique NAICS codes. The 2-digit NAICS codes begin with 32, 33, 42, and 44.

Unique EV Companies

The map and table below detail the unique EV automotive manufacturing companies present in Indiana, and the number of employees working at these companies. The size of the bubbles represents the number of companies in the county.



199

Count of Companies

9,816

Employees

9,031

Production Employees

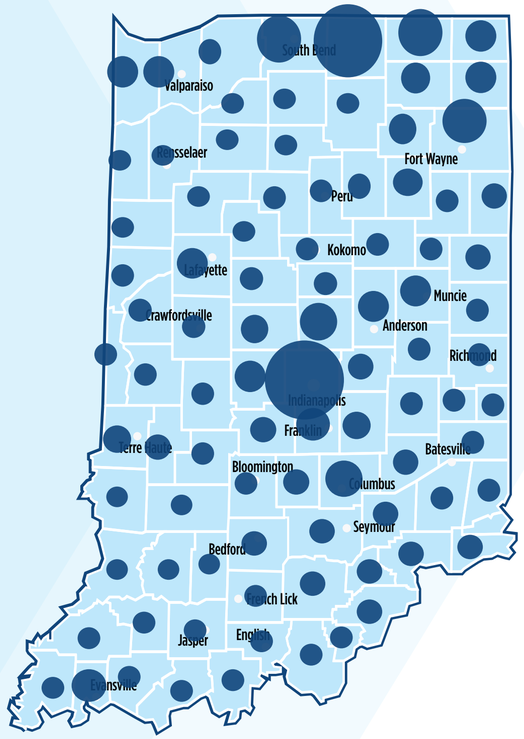
785

Craft Non-Production

Note: The Unique EV companies span over 22 unique NAICS codes. The 2-digit NAICS codes begin with 32 and 33.

Combined ICE and EV Companies

The map and table below detail the unique EV automotive manufacturing companies present in Indiana, and the number of employees working at these companies. The size of the bubbles represents the number of companies in the county.



3,535

Count of Companies

137,519

Employees

126,517

Production Employees

11,002

Craft Non-Production

Note: The Combined ICE and EV companies span over 108 unique NAICS codes. The 2-digit NAICS codes begin with 32, 33, and 42.

Inventory of Parts

The table shows the components for each ICE category of parts. These components are used as the keywords for the ICE and EV industry analysis based on the company description.

Category	Parts/Components
Automotive, Motor	Automotive, Motor
Engine and Engine Components	Pistons, valves, cylinder sleeves, camshafts, fuel, and exhaust systems
Cooling Systems	Air conditioning, Blowers, Heater
Electrical Systems	Electrical and electronics components
Drivetrain	Transmission components and axles
Brakes	Disc, Rotors, pads
Body	Stamping Parts
Interior	Instrument panel parts, seat belts, radio, seats, airbags
Trim	Leather, Fabric
Tires & Wheels	Tires, Wheels, Air Pressure Sensors
Glass	Windshields, side glass, roof glass

ICE Parts Descriptions

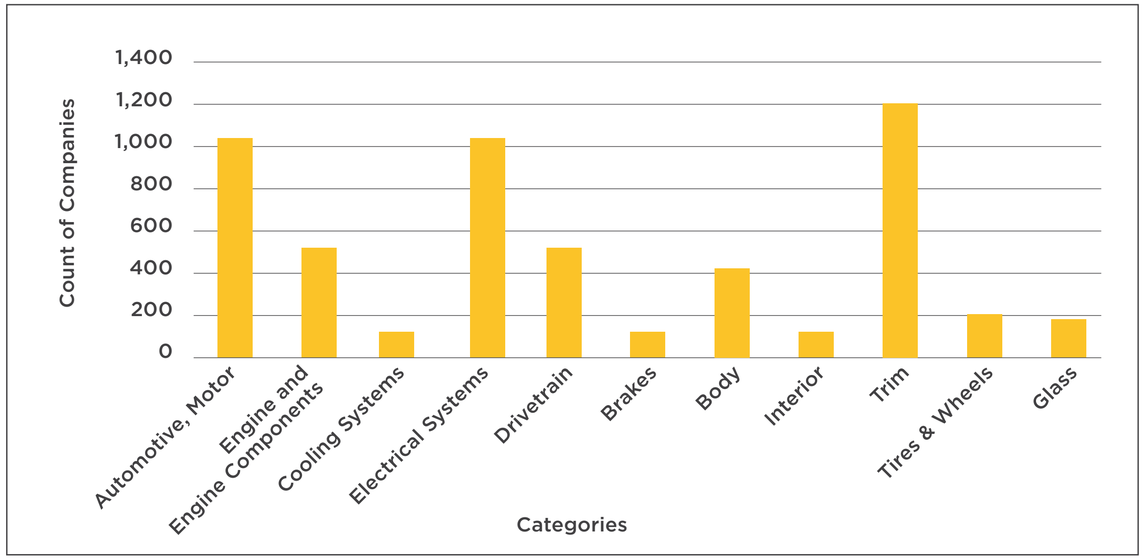
The table shows statistics including the count of companies, total employees, production employees, and non-production employees for each parts category for ICE vehicles.

Note: These statistics are only to be considered separately for each category because there can be companies that fall under multiple part categories.

Parts Category	Count of Companies	Total Employees	Production Employees	Non-Production Employees
Automotive, Motor	1,060	86,503	77,853	8,650
Engine and Engine Components	558	25,608	23,047	2,561
Cooling Systems	101	3,950	3,555	395
Electrical Systems	1,036	21,427	19,284	2,143
Drivetrain	540	12,690	11,421	1,269
Brakes	94	4,636	4,172	464
Body	433	19,808	17,827	1,981
Interior	112	4,619	4,157	462
Trim	1,213	31,726	28,553	3,173
Tires & Wheels	186	6,397	5,757	640
Glass	172	3,545	3,191	355

ICE Companies by Parts

The graph below provides a snapshot of the count of companies that are associated with each part category of ICE motor vehicles. Based on the analysis, there are 558 companies associated with producing Engine and Engine components and 540 companies associated with producing Drivetrains.



EV Parts Descriptions

The table below shows the components for each EV category of parts. These components are used as the keywords for the industry analysis from the company description.

Category	Parts/Components
Cooling Systems	Air conditioning, Blowers, Heater
Power systems	Energy storage, including battery R&D, manufacturing and assembly, and ultracapacitors
Motors	Motors or motor components
Wire Harnesses	Wire harnesses or wire materials
Braking	Braking system components
Electronic Controls	Power electronics and control equipment and software, including thermal management for battery packs
Recycling	Recycling of Battery components
Body	Stamping Parts
Charging systems	Home, business, Parking Lots, Apartment/condo complexes, Rest areas
Interior	Instrument panel parts, seat belts, radio, seats, airbags
Trim	Leather, Fabric
Tires & Wheels	Tires, Wheels, Air Pressure Sensors
Glass	Windshields, side glass, roof glass

EV Companies by Parts

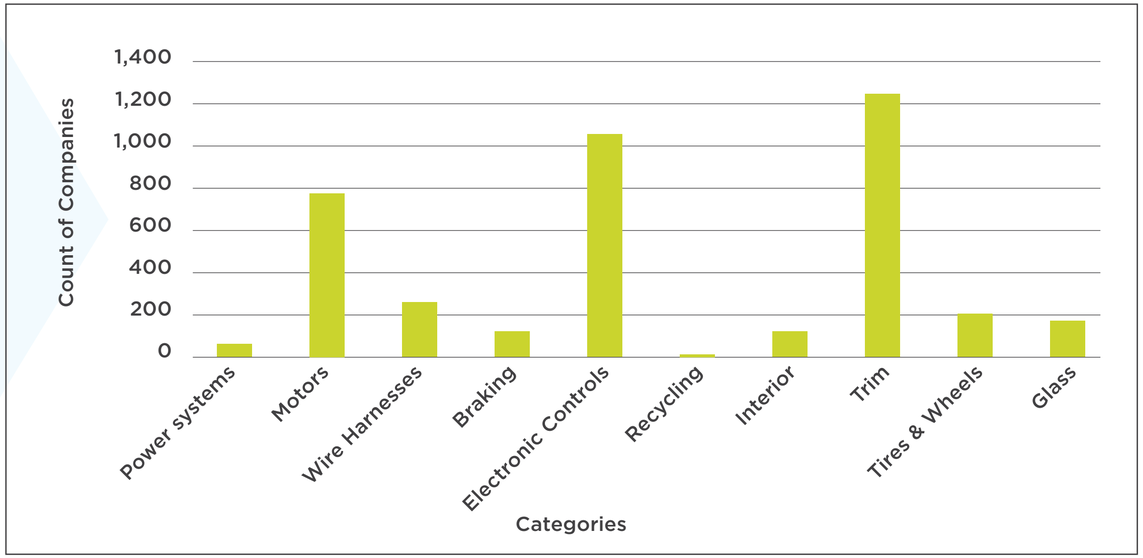
The table shows statistics including the count of companies, total employees, production employees, and non-production employees for each parts category of EV vehicles.

Note: These statistics are only to be considered separately for each category because there can be companies that fall under multiple part categories.

Parts Category	Count of Companies	Total Employees	Production Employees	Non-Production Employees
Power systems	41	9,438	8,494	944
Motors	752	65,654	59,089	6,565
Wire Harnesses	244	11,177	10,059	1,118
Braking	92	4,627	4,164	463
Electronic Controls	1,074	22,925	20,633	2,293
Recycling	5	296	266	30
Interior	112	4,619	4,157	462
Trim	1,210	31,663	28,497	3,166
Tires & Wheels	186	6,397	5,757	640
Glass	159	2,919	2,627	292

EV Companies by Part Description

The graph below provides a snapshot of the count of companies that are associated with each part category of EV vehicles. Based on the analysis, there are 1,074 companies that are associated with Electronic Components and five companies associated with the reuse of EV vehicles and components.



Evaluate opportunities and needs for training within the electric vehicle product industry.

Task 3

Evaluate opportunities and needs for training within the electric vehicle product industry.

One thing is certain: the traditional ICE processes and workforce competencies will migrate to new technologies as the EV sector continues to emerge.

As the technology in electric vehicles continues to develop and the mass production of EVs expands, the need for a more specialized workforce increases. Manufacturers will seek a workforce with both the traditional ICE competencies along with the ability to obtain new competencies—particularly with a digital focus. These will be competencies that are transferable from ICE to EV and will support different business models. Workers will need to possess not only these traditional competencies, but will need to add problem-solving skills, adaptability, a collaborative mindset, and an openness to change.

Ivy Tech Community College is state-legislated to serve industry partners statewide. The legislated mission is to partner with industry leaders and align programs to support workforce needs. Ivy Tech has a long-standing and collaborative relationship with Indiana manufacturers and academic institutions with a history of creating and implementing education and training to successfully develop and upskill the workforce. Additionally, Ivy Tech has produced a program addressing digital competencies and is currently developing a curriculum to support battery technology and production in collaboration with industry and university partners.

To better understand the types of workforce competencies and skills needed to produce ICE motor vehicles, the image and description below indicate the associated processes and, therefore, needed training with the relevant competency. The competencies listed below are color-coded to reflect associated technology training programs currently offered by Purdue University, Ivy Tech Community College, or Vincennes University.

Propulsion System Competencies: ICE

- Gear machining
- Welding
- Carrier machining
- Shaft machining
- Heat treat operations
- Spline rolling forming
- Deburring
- Case/Housing machining
- Assembly of tight tolerance components
- Leak testing
- Test stands
- Casting operations
- Block machining
- Valve body machining
- Pump housing machining

- **Machine Tool Technology**
- **Welding Technology**
- **Industrial Technology**

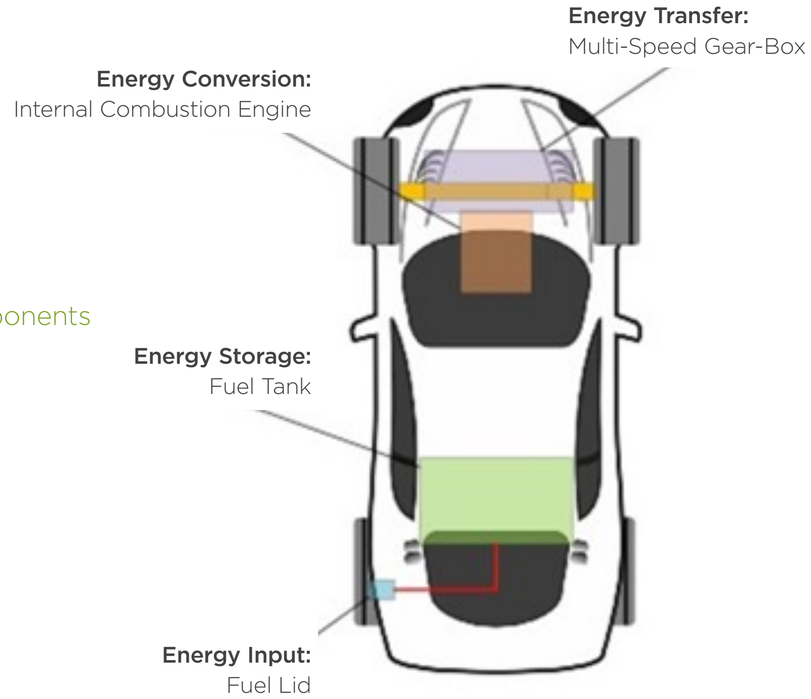


Image Source: EVP Commission

Workforce Skills Needed to Produce ICE Components

ICE Components

Engine
Transmission
Engine cooling system
Muffler and exhaust
Fuel system
Chassis
Steering
Braking
Suspension
Body
Frame
Interiors
Wheels

Worker Skills

- Ability to use tools and equipment
- Ability to read instructions and diagrams
- Physical ability to assemble parts
- Adhere to safety policy
- Problem solving
- Communication

To better understand the types of workforce competencies and skills needed to produce EV, the image and description below indicate the associated processes, and, therefore, training with the relevant competency. Of importance are the competencies identified in the black color, as they are competencies that the current automotive workforce is not yet proficient due to the current ICE processes not requiring these processes.

Propulsion System Competencies: EV

- Gear machining
- Welding
- Carrier machining
- Shaft machining
- Heat treat operations
- Spline rolling forming
- Deburring
- Case/Housing machining
- Assembly of tight tolerance components
- Leak testing
- Test stands
- Casting operations
- Block machining
- Valve body machining
- Pump housing machining
- Control Modules
- Software
- Computer Aided
- Cyber Security

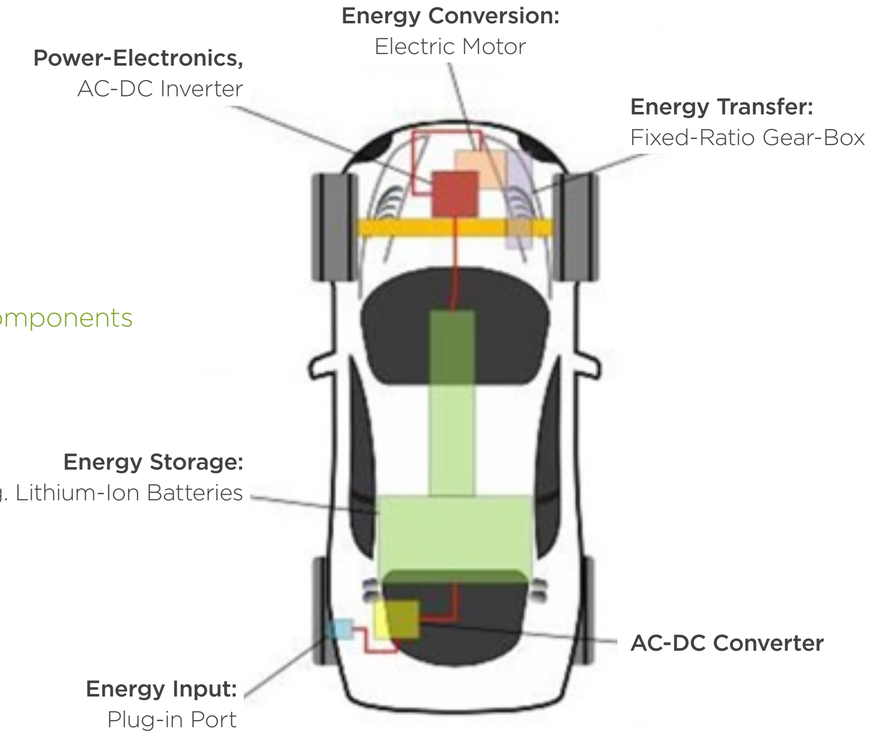


Image Source: EVP Commission

- **Machine Tool Technology**
- **Welding Technology**
- **Industrial Technology**
- **Smart Manufacturing/Digital Integration**

Workforce Skills Needed to Produce EV Components

EV Components

Electric powertrain
Electric motor
Electric power control
Electric powertrain thermal Management
Battery
High voltage power cables
Charging port and components
Chassis
Steering
Braking
Suspension
Body
Frame
Interior
Wheels

Worker Skills

- Advanced safety awareness regarding high-voltage battery
- More advanced safety equipmnet
- Voltage measuring tools
- Laser welding

Future Workforce Training Needs

Current Worker Skills

- Ability to use tools and equipment
- Ability to read instructions and diagrams
- Physical ability to assemble parts
- Adhere to safety policy
- Problem solving
- Communication

New EV Worker Skills

- Advanced safety awareness regarding high-voltage battery
- More advanced safety equipment
- Voltage measuring tools
- Laser welding

Lithium-ion cell

Module

Pack

Welding Technology

Smart Manufacturing/Digital Integration/TBD

- Battery cell manufacturing seen as skilled work
- Build upon traditional auto manufacturing competencies
- Battery Safety + High Voltage
- Battery Materials
- Collaborative Robotic Assembly
- Welding
- Recycle—Dismantling Second Life

Determine if training centers promoting careers in the electric vehicle product industry should be created or transitioned from traditional automotive industry training centers.

Task 4

Determine if training centers promoting careers in the electric vehicle product industry should be created or transitioned from traditional automotive industry training centers.

The research can be used to help build and up-skill the workforce by making education more accessible to populations near manufacturing centers around the state. While there are numerous education facilities available, there are large swathes of land that are not nearby training facilities. Industry 4.0 is pushing manufacturers to require new and different skills for production workers, and the proposed displacement of current auto workers will need to be addressed.

Specifically, Ivy Tech Community College has a strong relationship with the manufacturing sector that can be useful for the transition from ICE to EV. Alignment with satellite and workshop locations could allow the new and existing workforce more opportunities to gain the skills needed to be successful in the new manufacturing environment.

Ivy Tech Community College: Full-Service Locations

Full-service means that the locations have more departments, student services, and academic choices. Ivy Tech offers 19 locations that offer a full range of services.

Source: www.ivytech.edu/locations/

Ivy Tech Community College: Satellite Locations

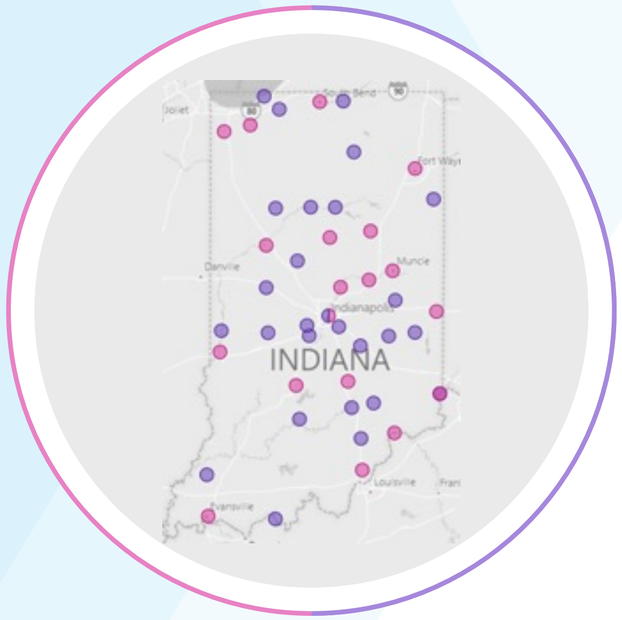
Satellite locations are usually single-room or single-building locations that offer a limited number of student services and academic choices. Ivy tech offers 27 satellite locations across the state of Indiana that branch off from one of the 19 Full-Service locations.

Source: www.ivytech.edu/locations/

Ivy Tech Community College: All Locations

Pink circles represent the 19 Full-Service campuses in Indiana.

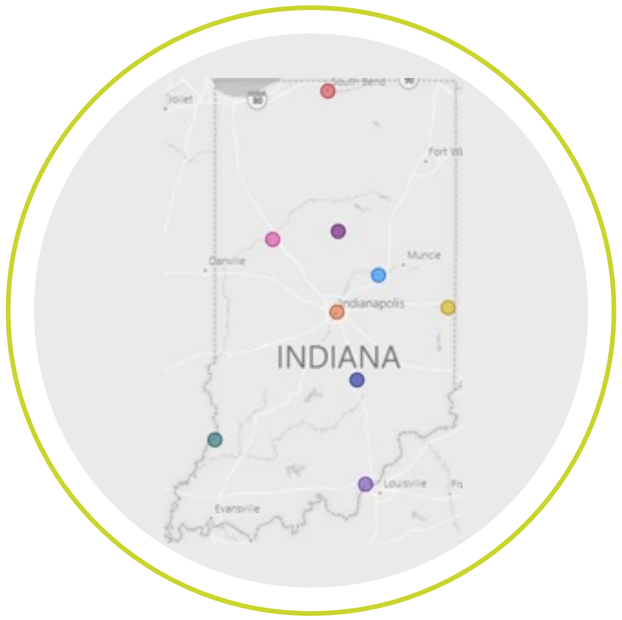
Purple circles represent the 27 Satellite locations.



Source: www.ivytech.edu/locations/

Purdue Polytechnic Institute Locations

- Anderson
- Columbus
- Indianapolis
- Kokomo
- Lafayette
- New Albany
- Richmond
- South Bend
- Vincennes



Source: https://polytechnic.purdue.edu/locations/location-info

Vincennes University Locations

- Vincennes
- Jasper
- Indianapolis
- Lebanon
- Fort Branch

Source: www.vinu.edu/campuses

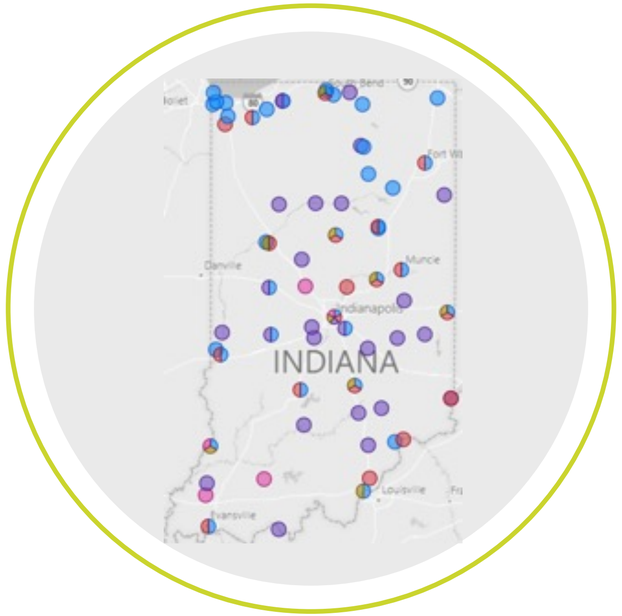
Four-Year Degree Universities Locations

In the state of Indiana, there are 63 4-year degree campuses. There is only one circle per county. Each color represents a university. Multicolored circles represent counties hosting various institutions.

- Butler University
- Indiana University
- Purdue University
- Rose Hulman Institute of Technology
- University of Indianapolis
- University of Notre Dame
- Vincennes University

ICE and EV Program Offered: Ivy Tech Community College, Purdue University, and Vincennes University

- 4-year degree institutions are blue circles (63)
- Ivy Tech Full-Service campuses are red circles (19)
- Ivy Tech Satellite locations are purple circles (27)
- Purdue Polytech Institute (4-year degrees) campuses are gold circles (9)
- Vincennes campuses are pink circles (9)



Gap Analysis

The map shows the locations of all education institutes (Ivy Tech college locations – satellite & full service, Vincennes college locations, Polytech college locations, and 4-year degree college locations) in the state and automotive manufacturing companies (Unique ICE, combined ICE & EV, and Unique EV).

The bi-colored circles identify locations with both industry and training locations are present. For the red circles, this represents an opportunity for expanded course offerings at or near these locations.

Disruption

As the electric vehicle product industry develops in Indiana, workers are a key component in this equation. Purdue University in its report Manufacturing Pain and Gain? - The EV Options in Indiana and Beyond"[1] suggests that there will be a disruption of the workforce.

The United Auto Workers (UAW) elaborates further in its report "Taking the High Road: Strategies For a Fair EV Future"[2] suggests that EVs could erode employment in engines, transmissions, exhaust systems, and fuel systems, however, in turn, it could create employment opportunities in batteries, electric motors, electronics, thermal systems, braking systems, and semiconductors. The bigger point is that the entire auto manufacturing supply chain is transforming and evolving – from the dozens of new battery plants that are being built (and likely mineral processing facilities) to also the recycling/reuse processing facilities as an example.

In answering the question regarding if training centers in the electric vehicle product industry should be created or transitioned from traditional automotive industry training centers—the short answer is yes. Research from EVP Commission has determined that the training centers need to evolve with the rest of the industry. There should be training centers placed throughout the state within the gaps that we have located for education centers in relation to the auto manufacturing supply chain thru assembly to recycle/reuse.

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[1] *Dr. Iyer, A. V., Dunlop, S. R., Dr. McLeod, A., Vasher, R., Thakkar, D. J. (2021). Manufacture: Pain or Gain? – The EV Options in Indiana & Beyond*

[2] *https://uaw.org/wp-content/uploads/2019/07/190416-EV-White-Paper-REVISED-January-2020-Final.pdf*

EV Education Portal

This EV Education Portal (Portal) is one example of a tool developed to help bridge the gap between traditional ICE manufacturing skills and new EV manufacturing skills. This Portal will have a landing page for accredited institutions in Indiana to offer courses and certificate programs for workers' skill development. Further, it will provide the ability for Indiana companies to customize learning pathways based on their specific manufacturing process and the needs of the workers.

This Portal is a unique collaboration of numerous educational institutions, including out-of-state entities that have deliberately coordinated and connected their course offerings to support the ICE and EV sectors. The Portal provides a large menu of courses for the retraining of existing workers and pathways for workforce pipeline development that includes Courses, Certificates and Academic programs, and Customized Learning Pathways.

www.evbatteryportal.org

What Needs to Shift in the Workforce?

The shift from producing ICE motor vehicles to EV will be significant. Control systems will be the most sophisticated than ever before, and the cybersecurity component to production will be critical. Furthermore, the size and weight of the new EV components will substantially impact the design and functionality of the plant. The information below provides a snapshot of additional considerations regarding the impact on the production and workforce that will touch every segment of the supply chain.

Battery Cell/Pack Manufacturing and Battery Supply Chain

- Anodes, cathodes, electrolytes, separators
- Battery recycling, refurbishment, and re-use
- Largely some competencies in chemical processing and refining industries

EV Charging Equipment Manufacturing (i.e. Residential, Workplace, and Public)

- Software
- Electrical Hardware
- Cords/cabling/adapters
- Charger installation and servicing
- Largely some competencies in the electrical equipment industry

Identify existing manufacturing competencies within the traditional automotive industry and determine how the existing competencies could be leveraged to increase the production of electric vehicles.

Task 5

Identify existing manufacturing competencies within the traditional automotive industry and determine how the existing competencies could be leveraged to increase the production of electric vehicles.

Since 1909, Indiana has grown its automotive manufacturing operations to **13 facilities, 32,600 careers, and more than 24 million square feet of facility space**. The momentum of investment and growth in the automotive industry has only kept growing, with one of the most recent notable investments being the U.S. semiconductor manufacturer SkyWater Technology Inc.'s plans to invest $1.8 billion for a chip research and production facility in Indiana, in partnership with the state and Purdue University.

The figures below demonstrate the expansive competencies of the ICE and EV workforce. While some misconceptions place much emphasis on assembly careers, many other roles will also need to be filled and/or retrained due to the process and product shift from ICE to EV. The ripple effect of this disruption is expected, but the breadth of the expansion of such a change in competencies is yet to be determined.

EV Propulsion System Competencies:

- Gear machining
- Welding
- Carrier machining
- Shaft machining
- Heat treat operations
- Spline rolling forming
- Deburring
- Case/Housing machining
- Assembly of tight tolerance components
- Leak testing
- Test stands
- Casting operations
- Block machining
- Valve body machining
- Pump housing machining

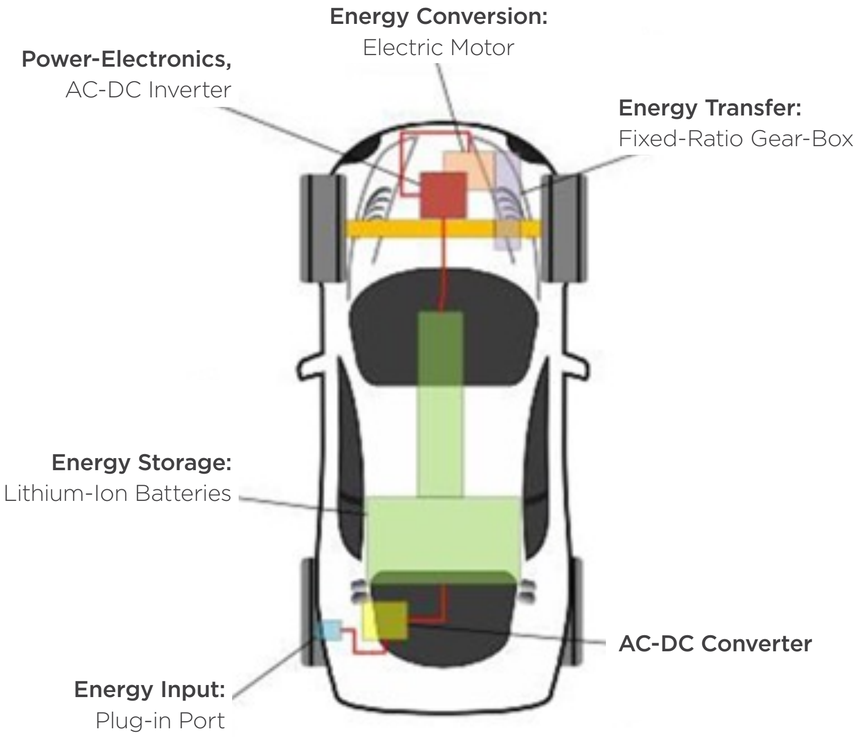

Image Source: EVP Commission

**Topics in green to include both ICE and EV Propulsion System competencies*

*Topics in green to include both ICE and EV Propulsion System competencies

Engineering Competencies: ICE

- Mechanical
- Electrical
- Facilities
- Environmental
- Chemical
- Industrial
- Software
- Computer-Aided

Engineering Competencies: EV

- Mechanical
- Electrical
- Facilities
- Environmental
- Chemical
- Industrial
- Software
- Computer-Aided
- Cybersecurity

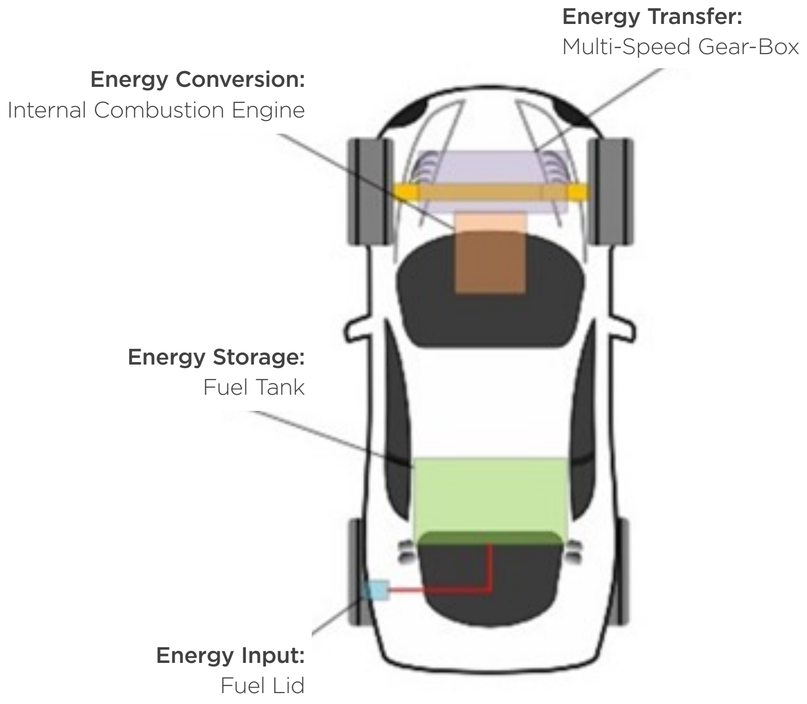

Image Source: EVP Commission

Labs and Garages

What Will Need to Shift?

The shift from producing ICE motor vehicles to EV will be significant. Control systems will be the most sophisticated than ever before, and the cybersecurity component to production will be critical. Furthermore, the size and weight of the new EV components will substantially impact the design and functionality of the plant. The information below provides a snapshot of additional considerations regarding the impact on the production and workforce that will touch every segment of the supply chain.

Manufacturing EVs

Technical and cybersecure manufacturing processes to assemble

- Lithium-ion batteries
- Electric motors
- Control modules

Sophisticated controls systems in every vehicle

- Require advanced diagnostic skills

Heavier components

- Collaborative robotic assembly
- Ergonomics focus

Emphasis on absolute safety concerning high-voltage components

Identify and evaluate opportunities for growth within the electric vehicle product industry.

Task 6

Identify and evaluate opportunities for growth within the electric vehicle product industry.

While the EV product industry has existed for some time, it has taken until recently to attain a level of sustainability. Within this growth and sustainability stage, there are key sectors and areas for advancement and differentiation.

Battery Second Life: Remanufacturing, Repurpose, Recycling

Increased EV production has increased the use of lithium-ion batteries for energy storage and raised the issue of what to do with post-vehicle-application batteries. Three possibilities have been identified: 1) remanufacturing for intended reuse in vehicles; 2) repurposing for non-vehicle, stationary storage applications; and 3) recycling, extracting the precious metals, chemicals, and other byproducts.

OEMs and the cottage industry have consistently been working on the Battery Second Life. Remanufacturing is a key opportunity for Indiana, as several Hoosier companies are co-located and working in this sector to address the market need and opportunity, including Allison Transmission and Cummins.

Additionally, the repurposement or reuse of the battery is a focus. Repurposing, with a focus on stationary energy storage applications and the development of battery management systems, is also a target, in addition to Recycling to recover the battery component materials using manual disassembly and acid leaching. Currently, the Heritage Group and reELEMENT are two Hoosier companies working in this realm.

Electronics: Battery Management Systems, Wiring, and the Balance of System

Battery Management Systems (BMS) monitor the parameters of rechargeable lithium-ion batteries and their cells. Fundamentally, BMS reduces the risks associated with harsh environmental conditions to optimize battery performance. As battery technology grows exponentially with the future of mobility, it is equally important to implement a robust battery management system to help balance the demand of the smart grid.

Software and Controls: Algorithms and Vehicle to Grid/Vehicle to Everything (V2X/V2G)

V2G stands for “vehicle to grid” and is a technology that enables energy to be pushed back to the power grid from the battery of an electric car. With electric vehicle-to-grid technology—also known as car-to-grid—a car battery can be charged and discharged based on different signals — such as energy production or consumption nearby.

V2X means vehicle-to-everything. It includes many different use cases such as vehicle-to-home (V2H), vehicle-to-building (V2B), and vehicle-to-grid services. Depending on whether one wants to use electricity from an EV battery to a home or building electrical loads, there are different abbreviations for each of these use cases.

In summary, the idea behind vehicle-to-grid is similar to regular smart charging. Smart charging, also known as V1G charging, enables one to control the charging of electric cars in a way that allows the charging power to be increased and decreased when needed. Vehicle-to-grid goes one step further and enables the charged power to also be momentarily pushed back to the grid from car batteries to balance variations in energy production and consumption.[2]

Infrastructure/Hardware: Charging and Deployment

The EVP Commission understands that if the infrastructure and hardware for EVs are not available, the EV industry will not grow. The EVP Commission’s work is meant to complement and align with Indiana’s second 21st Century Energy Task Force as it explores how fuel transitions and emerging technologies may affect the state’s electric system. Certainly, there is a need to continue to have the public infrastructure available to the general public and needs of varying degrees from level 1-3 in DC fast charging and readily available to support EV products.

[2] https://www.virta.global/vehicle-to-grid-v2g

Safety: First Responders and Infrastructure

First responders and supporting agents (fire, police, wrecking/salvage), among others should be equipped to understand, interact, and remediate EV products in the field. Life-cycle awareness and outreach are critical to capture their engagement and should include hands-on training and technical growth to skill-up the existing workforce and influence the next generation who are necessary to support the ongoing deployment of these technologies. Several EV companies in Indiana are already engaging directly with first responders and their supporting agencies to build awareness, training, and hands-on training including the Battery Innovation Center (BIC). Additionally, BIC along with Greater Indiana (Clean Cities) are conducting industry and community events to showcase Indiana's capabilities to not only organizations within the state and across multiple levels, but also outside of Indiana to highlight the significant initiatives.

Heavy Duty Truck and Bus

Indiana is the national leader in EV capabilities for Heavy Duty (HD) Trucks and Buses with Allison Transmission being one of the most notable from the hybrid perspective (HEV), along with Cummins and now Caterpillar pushing electrification as a key portion of their powertrain offerings (including Hydrogen for Cummins). As the "Crossroads of America", Indiana's location facilitates a match of Heavy Duty manufacturing with the regional logistics assets that favor short-haul routes where EVs can provide substantial benefits. These shorter, predictable routes are ideal to further build upon on the known capabilities and provide real-world application relevance. HD manufacturing and deployment also complements Indiana's infrastructure plans and deployment that are underway on our Hoosier corridors as they target key transportation routes and locations. Additionally, Indiana ports will see positive impacts of electrification on its daily performance, with prototype deployments in progress at the Port of Burns Harbor.

Complementary Technologies: Hydrogen and Fuel Cells

- Motorsports: Racing and Competition Proving
- Aerospace: EVTOL and Unmanned
- Ag: Sustainable Farming Future
- DoD: Security and Independence
- Integrators: Contract Manufacturing and Applied Engineering

Investment Announcements 2021-2022

Since late 2021, nearly 20 new investment announcements have been made throughout the State of Indiana. The articles below highlight the top recent investments.

- Indiana will be investing $100 million over five years in EV charging stations
- Illinois, Indiana, and Wisconsin join Whitmar's Lake Michigan EV charging circuit
- Stellantis in partnership with Samsung SDI will be building a $2.5 billion EV battery plant in Indiana
- Indiana could be home to LG, Honda joint US Venture to make EV Batteries
- "Indiana Auto Industry Begins Pivot to Growing EV Production"
- "With engaged voters & smart public policy, Indiana can lead on next-gen alternative fuels"
- Stellantis will invest $229 million in three plants in Indiana to upgrade plants for Evs"

- InoBat Auto and Ideanomics revealed to build R&D and Battery Production Facilities in Indiana and is Supported by Indiana
- General Motors is Planning to Invest Over $51 Million in One of its Indiana Facilities as a Part of Expanding Their Electric Vehicle Production
- Holcomb goes to South Korea to promote Indiana's Electric Vehicle Ambitions
- GM and LG Looking at Building a Fourth Battery Plant in Indiana
- "Indiana AEE Celebrates Passage of Electric Vehicle Charging Bill"
- Multibillion-dollar EV Battery Plant potentially coming to St. Joseph County
- Cummins struck a deal with Meritor for $3.7 billion, including debt, so that electric truck manufacturers purchase the entire drivetrain except the battery
- Allison Transmission Debuts Hydrogen Fuel Cell Vehicle Testing
- Allison Transmission is Developing a fully Electric Truck
- Allison Transmission Awarded $6.55 Million Contract to Come Up With the Next Generation of Electrified Transmission to US Army
- Allison's Egen FLEXTM Electric Hybrid Propulsion System Spurs Growth of Clean Transportation in the Midwest
- GM to invest nearly $500M to support EV production in Marion
- Toyota to Spend $803 Million in Indiana for 'Electrified' Models

Identify and document results from previous instances of retooling and transforming manufacturing facilities in the automotive industry.

Task 7

Identify and document results from previous instances of retooling and transforming manufacturing facilities in the automotive industry.

Many communities throughout Indiana have experienced significant retooling of their automotive manufacturing industries to keep up with the often-changing technology, workforce, and regulatory requirements of the automotive marketplace. One community that stands out as an exemplary model for successful retooling and transition of both technology and workforce is as Kokomo, Indiana.

Kokomo has long been a hub for automotive manufacturing in the Hoosier state from the time of Elwood Hayes to the current investments by Stellantis, Delphi, Borg Warner, and others. Like many other communities across Indiana and throughout the US, Kokomo faced a significant transition in the automotive industry in the late 1990s and early 2000s. Global economic forces made manufacturing in the US less competitive and a number of production operations that had been viable in Kokomo moved overseas including a major automotive semiconductor production operation as well as other electronics components that Kokomo had been a leader in. In the face of these headwinds, leaders from industry, academia, and government joined forces to work collaboratively to retool and prepare Kokomo from the next generation of automotive manufacturing with a focus on more electrified powertrains. The State of Indiana, Indiana Economic Development Corporation, City of Kokomo, Howard County worked together to incentivize and secure major investments by Stellantis that modernized many of their core operations in the community including casting, engine, and transmission production plants. Delphi also invested in development of hybrid and battery technology at their Kokomo operations supported in part by a major federal grant from the DOE awarded in 2009. Most recently these investments have led to the attraction of a $2.5B investment by Stellantis and Samsung SDI JV to build a world class battery manufacturing facility in the community that will employ 1,400 workers.

In addition to industry investment in capital equipment and infrastructure, education providers including Purdue University, Indiana University, and Ivy Tech Community College have provided training and certifications to workers in the region to prepare them for the more advanced digital, robotics, and other technical requirements associated with new approaches to automotive manufacturing. This has included the training of nearly 2,300 workers from Ivy Tech since 2010.

While the work is not over Kokomo has made tremendous progress in its retooling efforts and has remained one of the most globally competitive hubs for automotive manufacturing.

Identify opportunities for research and development within the electric vehicle product industry.

Task 8

Identify opportunities for research and development within the electric vehicle product industry.

EV product innovations have been a part of Indiana's legacy and will be critical to our success as relevant and leading players in electrification. New verticals are emerging every day that open the door for advanced development and key research to help fuel the next discoveries and breakthroughs. These areas are closely aligned with the aforementioned growth sectors and are augmented by finding ways to differentiate Indiana's engagement.

- Materials: Ceramics, Composites, Electrolytes, Balance of System
- Battery/cell chemistry and innovation
- Electrochemical Processing
- Semiconductors
- Manufacturing Techniques
- Hydrogen and Fuel Cell (Complementary)
- Autonomous Vehicles and Artificial Intelligence (AV/AI)

Additionally, the university and college systems in Indiana have been a cornerstone for research and development (R&D). Below is a snapshot of R&D excellence in the automotive sector.

HYDROGEN

While hydrogen has long been considered a promising fuel source for the automotive industry it has not scaled due to various economic and technical challenges. However, in recent years spurred by advancements in fuel cell technology, lower cost of hydrogen production at scale, and government incentives to pursue lower carbon sources of fuel, hydrogen has emerged as a viable option for advanced technology vehicles. Hydrogen is particularly attractive as a fuel source for heavy duty vehicles where weight and length of drive cycles can be prohibitive to battery powered EVs.

Indiana is well positioned to be a leader in hydrogen technology for both industrial and automotive uses. Indiana can produce clean hydrogen at scale by leveraging our industrial assets such as refineries together with our capacity to store CO2 though carbon capture and sequestration (blue hydrogen) or by connecting hydrogen production to our robust solar and wind energy generation assets (green hydrogen). In addition to accessing clean hydrogen fuel at scale, Indiana is home to a significant heavy duty automotive industry with companies like Cummins, Allison Transmission, Borg Warner, any others already investing in hydrogen technology.

Just as it has taken time for the EV industry to reach a point of maturity where the technologies and products are being manufactured and deployed at scale, it will take time for the hydrogen industry to scale. But as an early adopter and innovator Indiana can ensure that as the hydrogen technology and market grow our companies and workforce will be ready.

Indiana Based University R&D Centers Working on Electric and Advanced Automotive Technology

Purdue University

- EVeCTherm: Electric Vehicle Charging and Thermal Management.
- Joint Transportation Research Program (JTRP)
- Next-Generation Energy Technologies for Connected and Automated On-Road Vehicles (NEXTCAR)

IUPUI

- Transportation and Autonomous Systems Institute (TASI)
- Initiative for Electrified and Autonomous Mobility (IEAM)

University of Notre Dame

- The Center for Sustainable Energy at Notre Dame (ND Energy)

Indiana University

- Vehicle Autonomy and Intelligence Lab

Rose Hulman Institute of Technology

- Branam and Kremer Innovation Centers

Electric Vehicle Product Commission Tasking Report