EXECUTIVE SUMMARY

POWER ELECTRONICS & THERMAL SYSTEMS

GLOBAL EPICENTER OF MOBILITY
REVOLUTIONIZING THE DETROIT REGION

Detroit Regional Partnership

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IN THIS SUMMARY

The Global Epicenter of Mobility (GEM), a signature program of the Detroit Regional Partnership (DRP), is designed to enable growth and development of the advanced mobility industry in the 11-county Detroit Region. GEM and its strategic partners work together to create a smart, secure, and sustainable advanced mobility industry in Southeast Michigan. GEM's efforts were made possible by a four-year U.S. E.D.A. Build Back Better Regional Challenge grant award.

As part of its work, GEM provides its grant partners and regional stakeholders with key mobility sector research, data, and insights. In 2024, GEM commissioned a Future Mobility Technology Study (FMTS) in collaboration with S&P Global Mobility. The FMTS is a comprehensive report that identifies the seven advanced mobility technologies with the strongest mid-term growth potential in the Detroit Region. Together with supporting data from other key sources, FMTS serves as the foundation of the Road to 2030 website.

This website covers the key insights from the FMTS, as well as other reports and key sources. Our content includes an executive summary of opportunities stemming from each of the seven technologies covered in the FMTS. The executive summaries, as well as a corresponding section of the Road to 2030 website, will be released over the course of the year. This executive summary, the fourth in our series, is focused on Power Electronics & Thermal Systems (PE&TS).

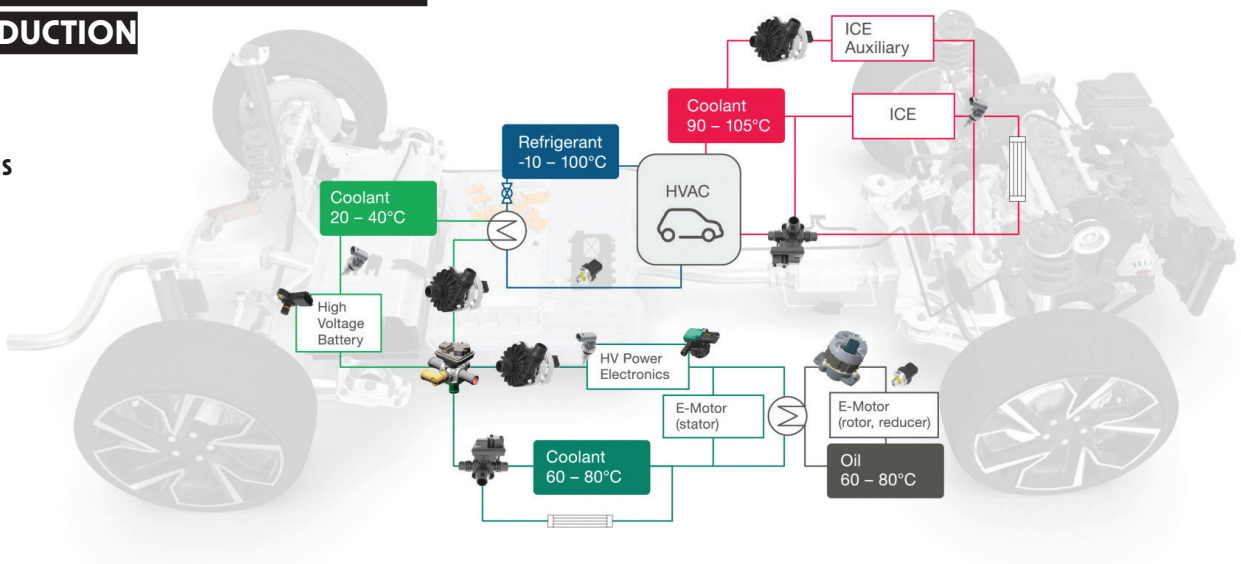
The FMTS is a comprehensive report that identifies the seven advanced mobility technologies with the strongest mid-term growth potential in the Detroit Region.

POWER ELECTRONICS & THERMAL SYSTEMS (PE&TS) INTRODUCTION

FIGURE 1:

POWER ELECTRONICS & THERMAL SYSTEMS (PE&TS) KEY COMPONENTS

SOURCE: VITESCO TECHNOLOGIES



Power Electronics and Thermal Systems (PE&TS) technologies are critical in electrified vehicle propulsion. The unique challenges of maintaining optimal operating temperatures of various powertrain components, particularly batteries, require robust thermal management systems. Likewise, the large amounts of electricity being transferred from the charging port to the battery and then from the battery to a vehicle's motors require complex power electronics systems both to transfer energy efficiently, but also to ensure that the entire powertrain is operating safely. Together, they ensure that the large amounts of electrical and thermal energy involved in powering a vehicle are both optimized and safely managed.

Power Electronics and Thermal Systems components are typically both installed on electrified vehicles in tandem, resulting in matching statistics regarding production volumes, technology penetration rates, etc. The only exception to this pattern is the First & Last Mile (commercial drone) sector, in which Power Electronics are always necessary (resulting in a 100% penetration rate) and typical Thermal Systems are not used. This analysis therefore presents data for these two technologies together, with specific mobility sector applications identified throughout.

The key components comprising Power Electronics systems are the DC-DC Converter, AC-DC Inverter, and On-board Charger. The AC-DC Inverter converts DC (Direct Current) from the battery into AC (Alternating Current) to drive the electric motor. The DC-DC Converter modulates voltage levels — usually high-voltage DC from the main battery to low-voltage DC for vehicle electronics. The key components comprising battery Thermal Systems are the Heat Exchanger, Battery Coolant System, Fan System, and Refrigerant System. Together, these components are used to maintain optimal temperatures both in the vehicle cabin and in key powertrain components such as the battery and Power Electronics components. This temperature optimization is typically a cooling function, though operation in cold temperatures may result in a need to warm the battery or vehicle cabin.

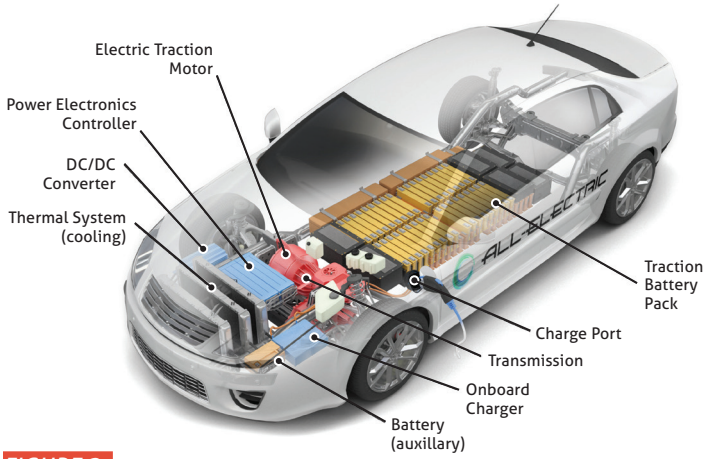


FIGURE 2:

POWER ELECTRONICS KEY COMPONENTS

SOURCE: U.S. DEPARTMENT OF ENERGY, ALTERNATIVE FUELS DATA CENTER

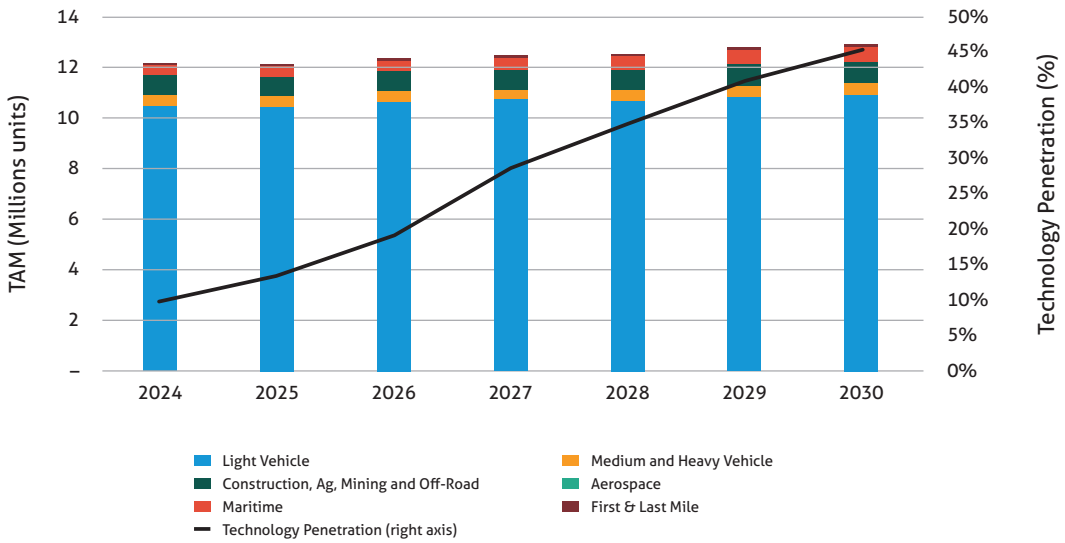
KEY TAKEAWAY

PRODUCTION & EMPLOYMENT GROWTH FORECASTS

Chart 1:

POWER ELECTRONICS & THERMAL SYSTEMS (PE&TS) TAM & PENETRATION RATE, ALL U.S. MOBILITY SECTORS

SOURCE: S&P GLOBAL LV/ MHCV/OFF-HIGHWAY PRODUCTION FORECASTS, S&P GLOBAL ANALYSIS WITH INDUSTRY SOURCES (GAMA, NMMA, FAA, AUVSI)



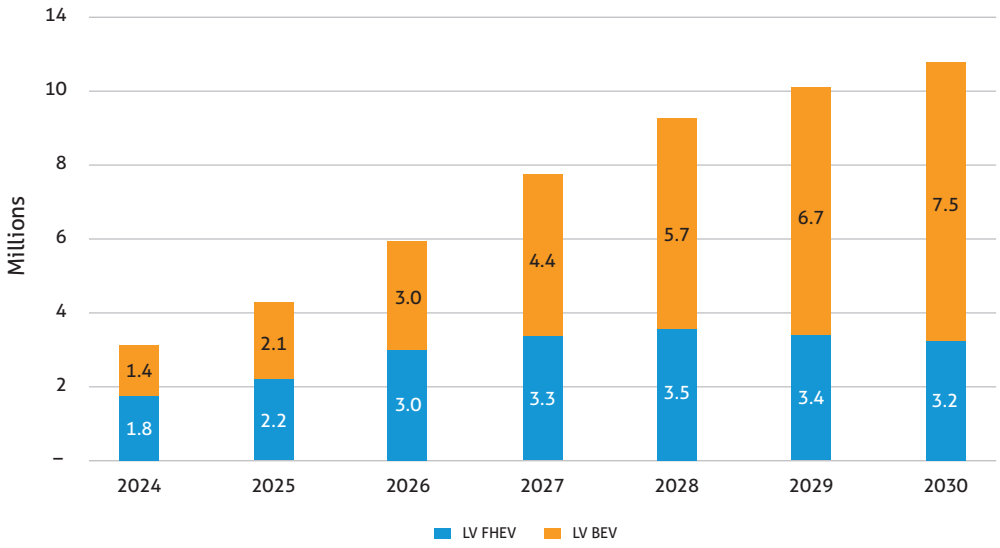
The Total Addressable Market (TAM) represents the total number of vehicles produced on which a given technology can potentially be deployed. The TAM is the same for Power Electronics and Thermal Systems technologies with the exception of the First & Last Mile (commercial drone) sector, which is only applicable to Power Electronics. Since this sector represents just 0.5% of the TAM in 2025 and .6% in 2030, the volumes are nearly identical.

The combined technology penetration rate for these technologies is expected to grow significantly, reaching over 45% by 2030.

Chart 2:

LIGHT VEHICLE THERMAL SYSTEM PRODUCTION, N.A.

SOURCE: S&P GLOBAL LV/ MHCV/OFF-HIGHWAY PRODUCTION FORECASTS, S&P GLOBAL ANALYSIS WITH INDUSTRY SOURCES (GAMA, NMMA, FAA, AUVSI)



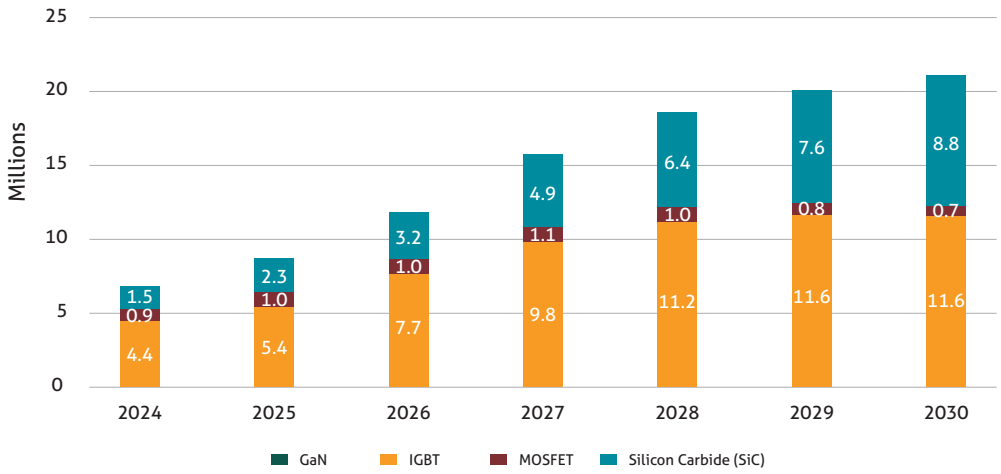
Light Vehicles (LVs) comprise about 98% of United States (U.S.) Thermal System production, which is distributed between Full Hybrids (FHEV) and Battery Electric Vehicles (BEV).

While Thermal System production for FHEVs is forecast to increase by 78% from 2024 to 2030, production for BEVs is forecast to grow by 436% over the same time-period.

Chart 3:

LIGHT VEHICLE POWER INVERTER PRODUCTION, N.A.

SOURCE: S&P GLOBAL MOBILITY

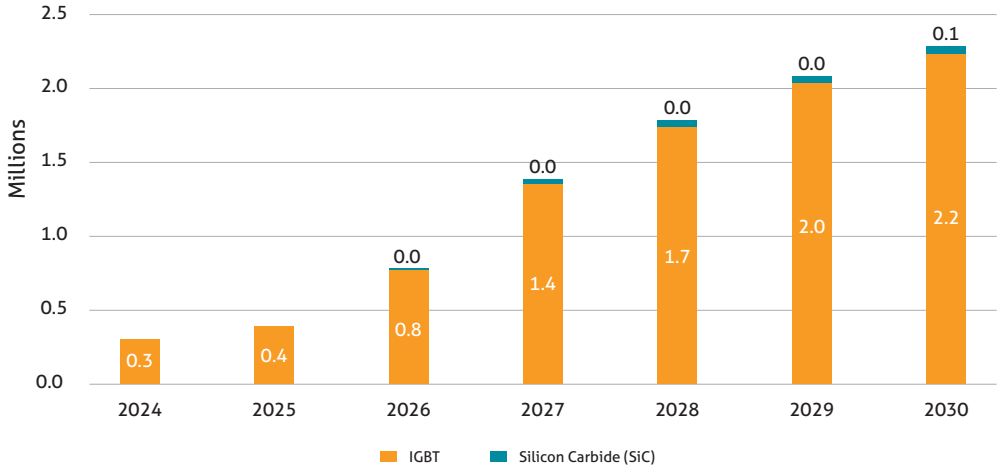


Total North America (N.A.) Power Inverter production is forecast to grow significantly, from 6.8 million units in 2024 to over 21 million by 2030. This growth represents a 209% increase from 2024 levels. Silicon Carbide inverters are forecast to experience the largest growth, with 2030 volumes 487% higher than in 2024.

Chart 4:

MICHIGAN LIGHT VEHICLE POWER INVERTER PRODUCTION

SOURCE: S&P GLOBAL POWER ELECTRONICS: INVERTER FORECAST, JULY 2024

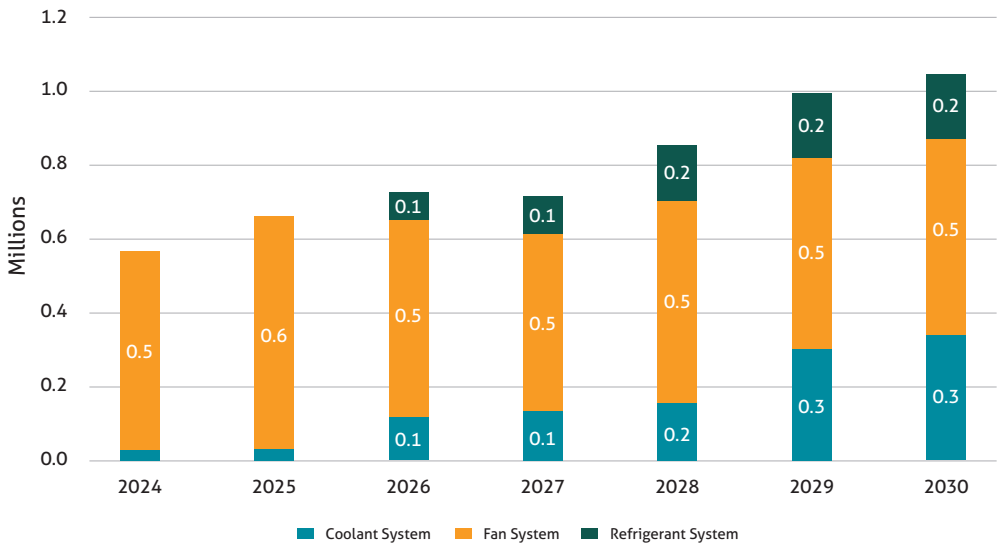


Light Vehicles are the mobility sector of greatest significance to Michigan and the Detroit Region. Michigan Power Inverter production for Light Vehicle applications is forecast to increase from approximately 300,000 units in 2024 to over 2.8 million units in 2030 – an increase of more than 833%.

Chart 5:

MICHIGAN LIGHT VEHICLE THERMAL SYSTEMS PRODUCTION

SOURCE: S&P GLOBAL MOBILITY SOFTWARE VEHICLE DOMAIN FORECAST, JULY 2024

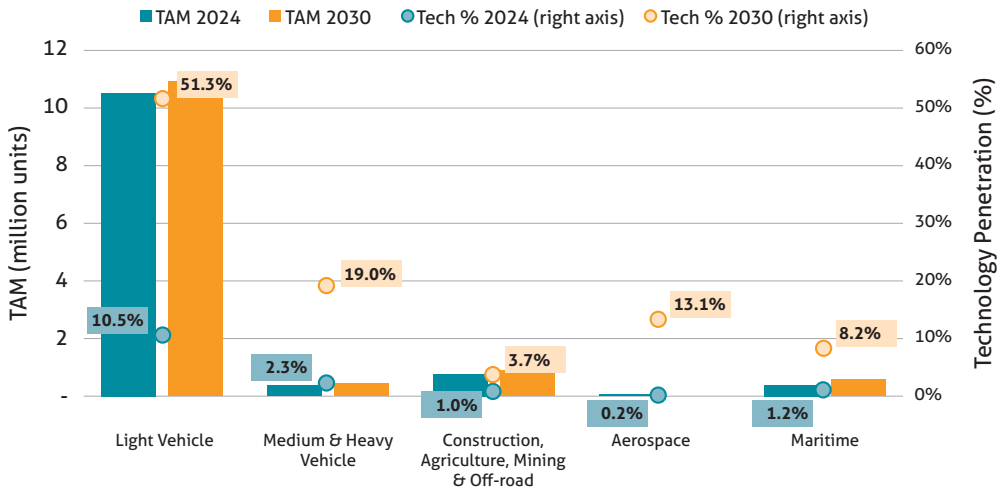


Michigan Thermal System production for Light Vehicle applications is forecast to increase from about 566,000 units in 2024 to over 1 million units in 2030 – an increase of nearly 85%.

Chart 6:

U.S. POWER ELECTRONICS & THERMAL SYSTEMS (PE&TS) TOTAL ADDRESSABLE MARKET (TAM) AND PENETRATION RATES

SOURCE: S&P GLOBAL LV/ MHCV/OFF-HIGHWAY PRODUCTION FORECASTS, S&P GLOBAL ANALYSIS WITH INDUSTRY SOURCES (GAMA, NMMA, FAA, AUVSI)



While the light vehicle mobility sector remains the largest opportunity for PE&TS applications through 2030, other sectors are also expected to experience significant growth in electrification and therefore usage of PE&TS components.

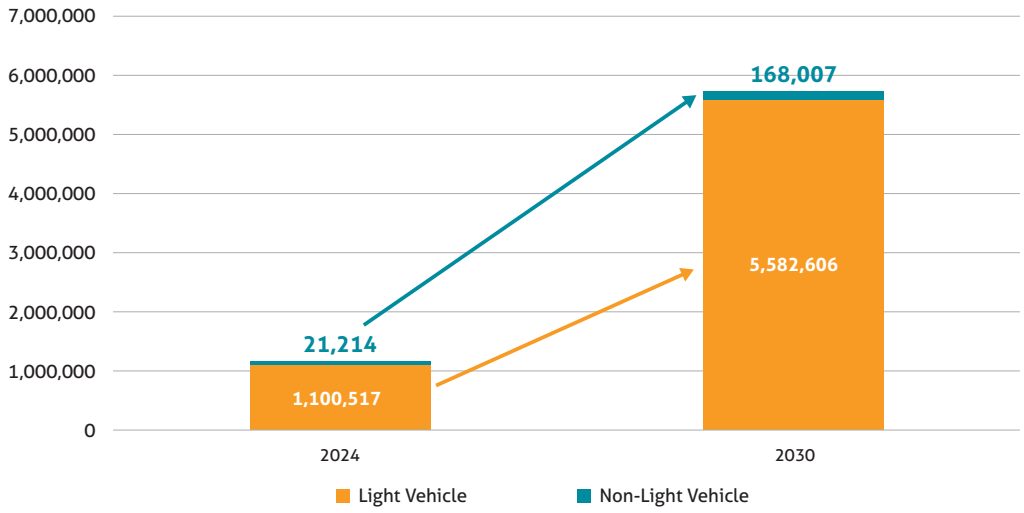
- **Medium- and heavy-duty vehicles**: PE&TS adoption is projected to rise from 2.3% in 2024 to 19% in 2030.
- **Aerospace**: Because aerospace applications don't employ the Thermal Systems technologies used in other mobility sectors, the data presented is for Power Electronics systems only. Although total unit volumes remain relatively low—just over 4,000 units by 2030—the PE penetration rate is expected to grow from 0.2% in 2024 to 13.1% in 2030. In June 2025, the Trump Administration announced several executive orders intended to advance U.S. development and production of drones and electric Vertical Takeoff and Landing (eVTOL) aircraft. The executive orders are intended to "accelerate the development, testing, and scaling of American drone technologies, including advanced air mobility and autonomous operations" and may further accelerate PE production for the Aerospace sector.
- **Maritime**: PE&TS application is forecast to increase from 1.2% in 2024 to 8.2% in 2030.

These forecasts include both fully battery-powered vehicles and hybrid or plug-in hybrid models that incorporate internal combustion engines.

Chart 7:

U.S. POWER ELECTRONICS & THERMAL SYSTEMS (PE&TS) PROJECTED GROWTH BY MOBILITY SECTOR

SOURCE: DRP/GEM ANALYSIS OF DATE FRAM S&P GLOBAL MOBILITY

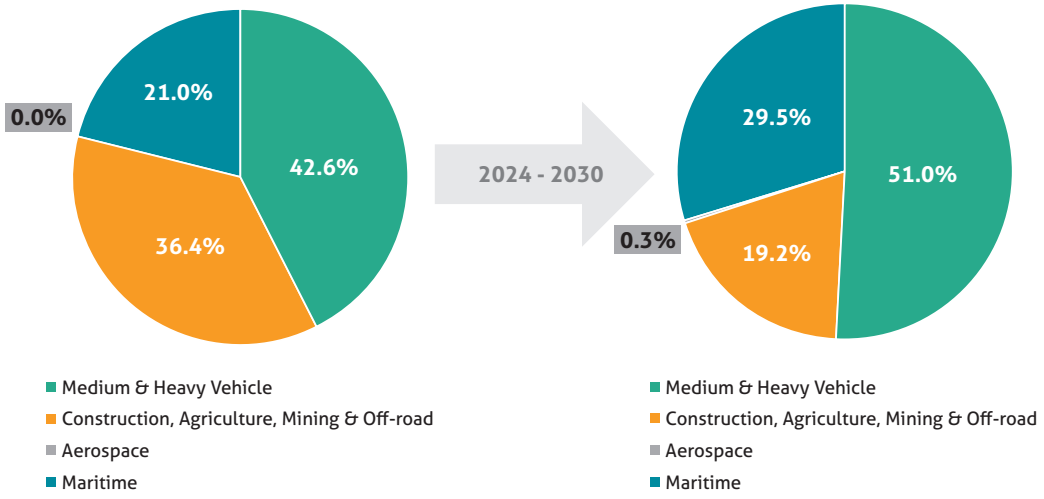


U.S. PE&TS demand for light vehicles is forecast to grow fivefold between 2024 and 2030. Over the same time-period, PE&TS demand for non-light vehicle mobility sectors is forecast to increase by 692% to over 168,000 units.

Chart 8:

NON-LIGHT VEHICLE POWER ELECTRONICS & THERMAL SYSTEMS (PE&TS) SHARE FORECAST

SOURCE: DRP/GEM ANALYSIS OF DATE FRAM S&P GLOBAL MOBILITY



While light vehicles will continue to represent the highest volume use for PE&TS, other mobility sectors are expected to undergo transformative shifts in electrification and PE&TS deployment through 2030.

- **Construction, Agriculture, Mining, and Off-road**: this sector's share of PE&TS applications is expected to decrease from 36.4% in 2024 to 19.2% in 2030. While this trend represents a decline in the share of applications constituted by this sector, actual application volumes will nearly quadruple over this time-period, reaching over 32,000 units by 2030.
- **Medium- and Heavy-Duty Vehicles**: Applications for this sector dominated U.S. PE&TS demand for non-light vehicle mobility sectors in 2024, with a share of 42.6%. By 2030, this sector is forecast to reach 51% of non-light vehicle PE&TS applications.
- **Maritime**: Applications are expected to increase from 21% in 2024 to 29.5% in 2030.

Although aerospace applications are expected to grow in penetration, low production volumes will limit their share to just 0.3% of non-light vehicle PE applications by 2030.

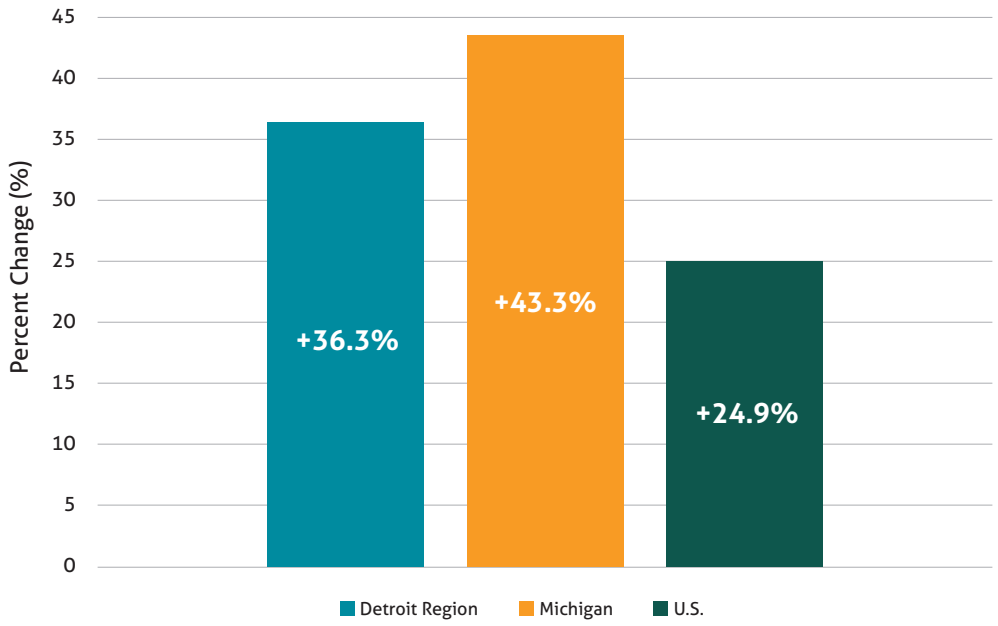
KEY TAKEAWAY

EMPLOYMENT IMPACTS AND FORECASTS

Chart 9:

U.S. AND MICHIGAN POWER ELECTRONICS & THERMAL SYSTEMS (PE&TS) PRODUCTION EMPLOYMENT

SOURCE: LIGHTCAST DATA AND FORECAST FOR NAICS 334413, 334418, AND 335999



Power Electronics production is distributed between NAICS 334413, 334418, and 335999. Between 2020 and 2030, employment in included jobs is forecast to increase by 36.3% in the Detroit Region and 43.3% in Michigan - significantly higher than the 24.9% growth expected at the national level.

Because Thermal Systems are included in the broader 336390 NAICS code, which includes all powertrain cooling products as well as general vehicle components, a breakout forecast for this technology is not available.

POWER ELECTRONICS & THERMAL SYSTEMS (PE&TS) WORK ACROSS THE DETROIT REGION

The Detroit Region is a global leader in the development and production of electrified powertrain components, including PE&TS. Perhaps the best example of this leadership is the University of Michigan Electric Vehicle Center (EVC) in Ann Arbor.

The EVC supports research and innovation in Power Electronics systems as part of its broader mission to advance electric mobility technologies. Its work in this area includes the optimization of electric drive modules, inverters, and energy conversion systems that connect batteries to electric motors. The EVC collaborates with university departments such as Electrical and Computer Engineering and Mechanical Engineering to advance designs that improve system efficiency, reliability, and power density in vehicle propulsion systems. The EVC partners with automakers and suppliers to develop next-generation Power Electronics architectures critical to improving performance and reducing the cost of electric vehicles.

The EVC also conducts significant work on Thermal Systems. Research at the center addresses the cooling and temperature regulation of batteries, electric motors, and power electronics modules, focusing on energy-efficient designs and integrated vehicle-level thermal strategies. This includes the development of new materials, advanced heat exchangers, and system-level modeling.

The efforts of the EVC are supported by numerous entities in the Detroit Region, including the Advanced Machines & Power Electronics Design (AMPED) Laboratory at Kettering University in Flint, Michigan. The AMPED focuses on the development and testing of electrical machines and power-electronic circuit system prototypes.

IMAGE SOURCE: UNIVERSITY OF MICHIGAN ELECTRIC VEHICLE CENTER

CONCLUSION

Power Electronics & Thermal Systems (PE&TS) are at the heart of the electrification transformation of the mobility industry. The optimization of the components that comprise these systems is essential to improving the performance and efficiency of electrified powertrains. The Detroit Region's proven engineering and product development expertise presents an opportunity to lead in the deployment of these critical technologies. The Detroit Region also boasts an unequaled wealth of mobility firms and suppliers producing components used throughout the PE&TS value chain.

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