DRIVING THE FUTURE

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July 16, 2018

MOTOR VEHICLE PARTS SUPPLIERS ARE THE **LARGEST** SECTOR OF **MANUFACTURING JOBS** IN THE **U.S.**

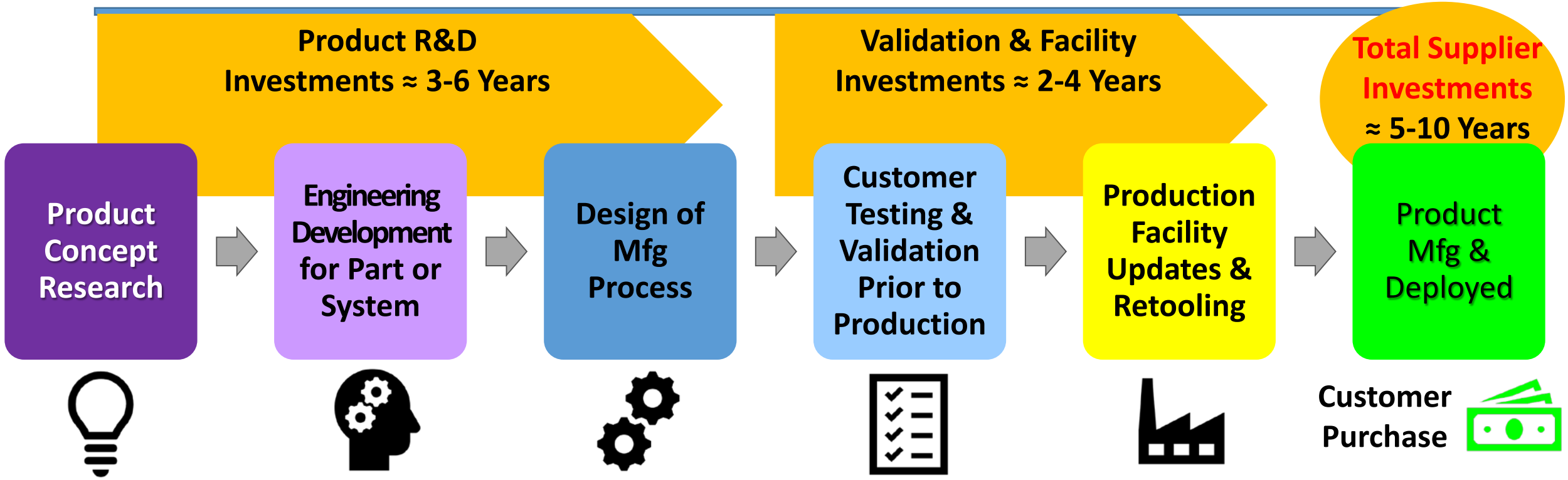
All data from "The Employment and Economic Impact of the Vehicle Supplier Industry in the U.S." based on research undertaken by IHS Markit on behalf of MEMA

Future Fuel Efficiency Technology Uncertain

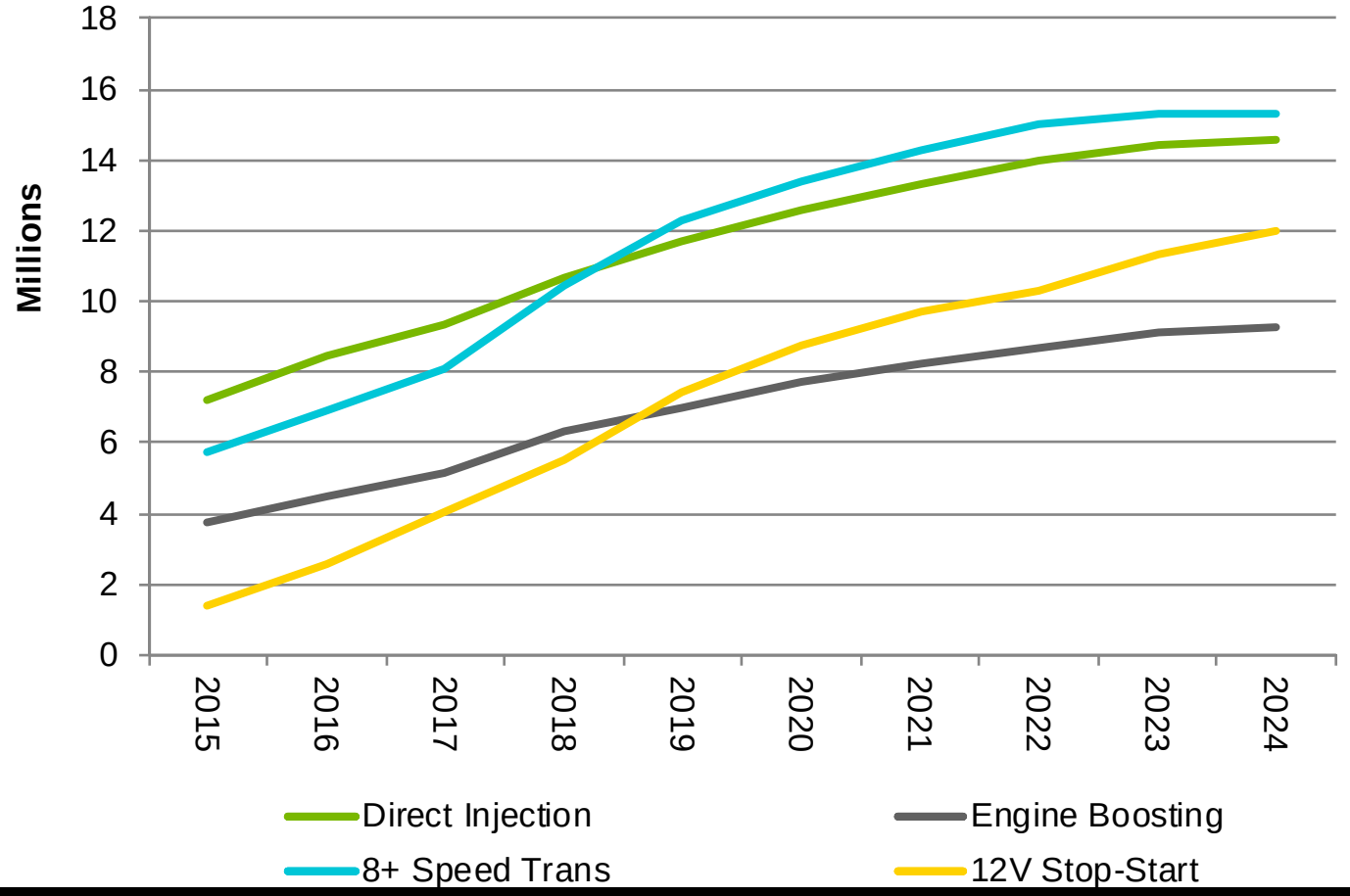
- Uncertainty exists on the direction of technology investments for MY2025 and later:
  - Regulatory uncertainty with fluctuating fuel economy targets
  - Consumer fuel efficiency demand, often driven by fuel prices, can be unpredictable and volatile
- Major R&D and capital investments are required; These could be stranded if OEM/consumer demand is lower than expected
- Increased risk as advanced technologies are introduced rapidly

Source: LMC Automotive

Supplier Investment in Technology: Why Suppliers Take On Much of the Risks



Low-Hanging Fruit Being Picked Quickly



Source: LMC Automotive

Interim ICE Technologies (2018 – 2025)

- Downsized engines with turbocharging or supercharging
- Continuously variable valve duration
- Cylinder de-activation – Ex: 3 cylinder to 2 cylinder
- Twin charging – turbocharger with an electric supercharger
- Hybrid electric versions of the above

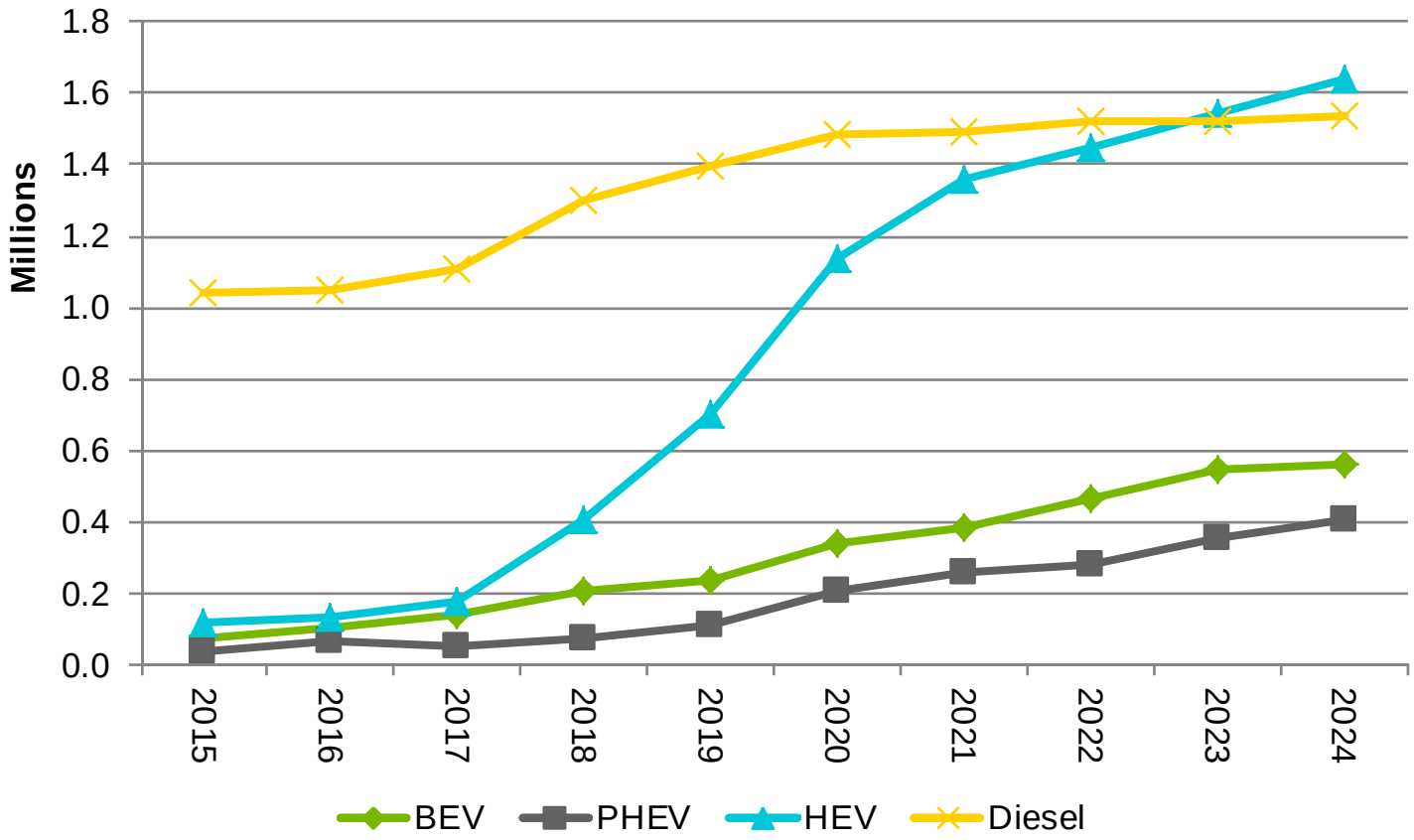
Source: Mazda

Interim Electrification Technologies (2018 – 2025)

- Dramatically increased use of start/stop systems
- Significant, sustained increase in HEV sales – mostly mild hybrids
- Gradual, but steady increase in BEV sales
  - Primarily for compliance - still not competitive with ICEs
  - Increasing BEV range

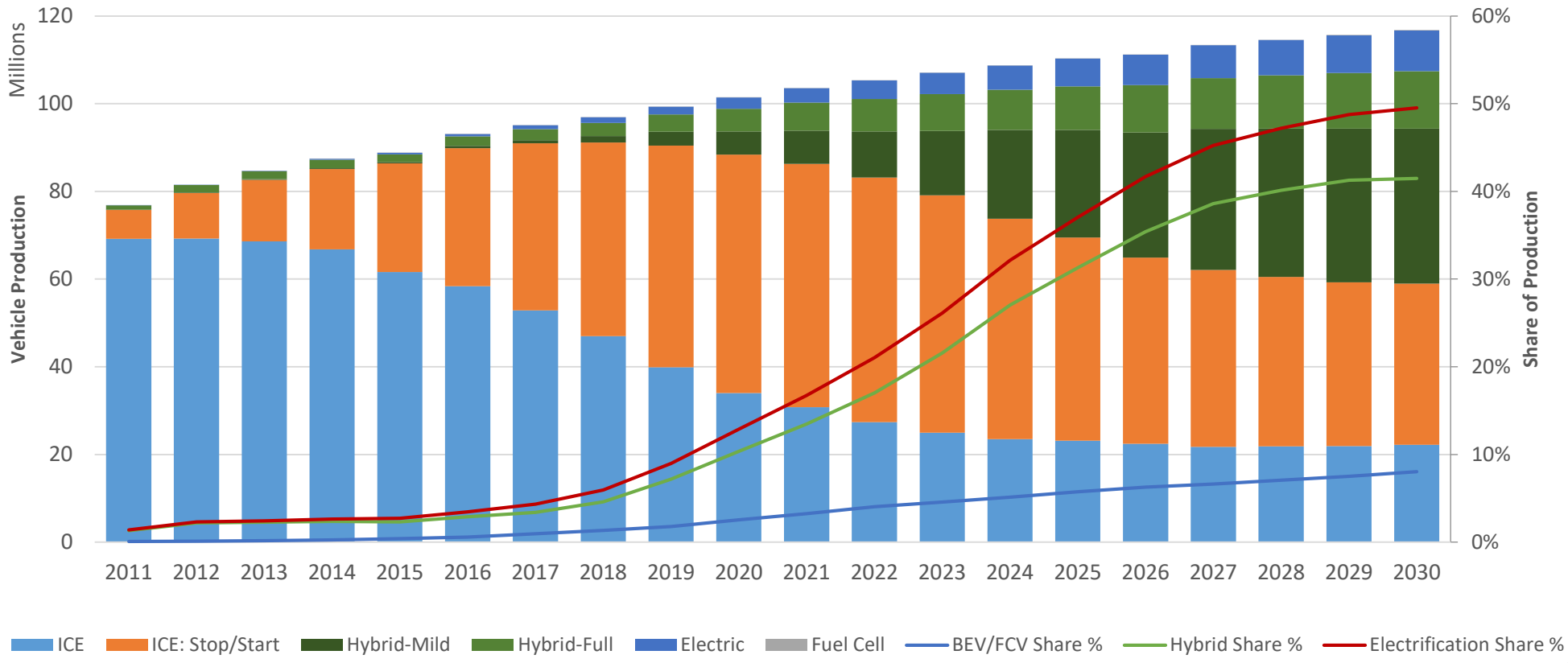
Source: LMC Automotive

HEV Sales are Projected to Increase Dramatically, While BEVs Slowly Increase



Source: LMC Automotive

Global Vehicle Production by Propulsion System



Source: IHS-Markit

New Combustion Technologies Post-2025

- Homogeneous Charge Compression Ignition (HCCI)
  - The goal is simultaneous combustion of the fuel-air mixture across the cylinder
- Mazda Spark Controlled Compression Ignition (SPCCI)
  - Adds spark ignition to HCCI. An additional injection of fuel plus a spark is used to create a pressure wave that triggers compression ignition across the rest of the cylinder
  - 20% improvement in fuel economy and 30% more torque
  - More responsive engine and better performance at high engine speeds

Source: Mazda

ICE Thermal Efficiency Comparison

• Traditional gasoline ICE		30% - 35%
• BIC production gasoline ICE		41%
• Diesel ICE		45%
• BIC large, low rpm ship diesel		50%
• Mazda SkyActiv-X	MY2020 Mazda 3	44%
• Mazda SkyActiv-3	MY2023	56%
• Hyundai and Toyota target		50%

Source: OEMs

Other Post-2025 Technologies

- Potential battery technologies for battery electric vehicles (BEVs)
  - Solid state
  - Nanowire
  - Sodium-ion
  - Graphene-based
- Improved vehicle connectivity and safety technologies reduce congestion and improve safety
- Dramatic lightweighting

Source: LMC Automotive

Summary

- The low-hanging fuel efficiency technology fruit is being picked rapidly; existing technologies will be deployed at increasing rates through 2025

- Regulatory certainty improves investment in fuel efficiency technologies

- Post-2025 technologies to watch include: solid state batteries and advanced high-efficiency ICEs

Source: LMC Automotive