



AUTOMOTIVE WIRE HARNESS ASSESSMENT

November 2019

Legal Statement

The purpose of the information in this presentation is to guide ICA programs and provide members information to make independent business decisions.

Findings are based on primary interviews conducted in the industry and publicly available information.

Antitrust Guidelines

Antitrust Guidelines for Copper Industry Trade Association Meetings

The following guidelines with respect to compliance with antitrust laws of the United States, Japan and European Community¹ are intended to govern the conduct of participants in copper industry trade association meetings, both at the meeting itself and in informal discussions before or after the formal meeting.

Price: Competitors should not discuss future prices (including terms of sale) of their products. There is no blanket prohibition against the mention of or reference to current or past prices but limits must be observed. Such references or mentions should occur only when necessary in connection with the development of association programs. For example, reference to a particular price level in comparing the cost of a copper product to a competing product is permitted. Whenever possible, such references should be discussed in advance with legal counsel.

Competitive Information: Competitors should not discuss the market share of a particular copper producer or copper fabricator's products. Furthermore, nothing should be said at a meeting which could be interpreted as suggesting prearranged market shares for such products or producer production levels. The overall market share of copper products may be discussed with regard to competition with non-copper products and general market acceptance.

New Products: Competitors should not encourage or discourage the introduction of a new product by another competitor or reveal a particular copper company's plans to change the production rate of an existing product or to introduce a new product. No company should disclose to another company whether it is in a position to make or market a new product. New products may be discussed in a technical manner or from the standpoints of competition with non-copper products and general market acceptance. In addition, proposed methods for and results of field and laboratory testing can be considered.

The Role of Legal Counsel: Legal counsel attends association meetings to advise association staff and other meeting attendees regarding the antitrust laws and to see that none of the matters discussed or materials distributed raise even the appearance of antitrust improprieties. During the course of a meeting, if counsel believes that the discussion is turning to a sensitive or inappropriate subject, counsel will express that belief and request that the attendees return the discussion to a less sensitive area.

A paper entitled 'Copper Industry Trade Associations and Antitrust Laws' is available upon request.

10/92, 5/93, 10/10

1. Other foreign competition laws apply to International Copper Association, Ltd. (ICA)'s activities worldwide.

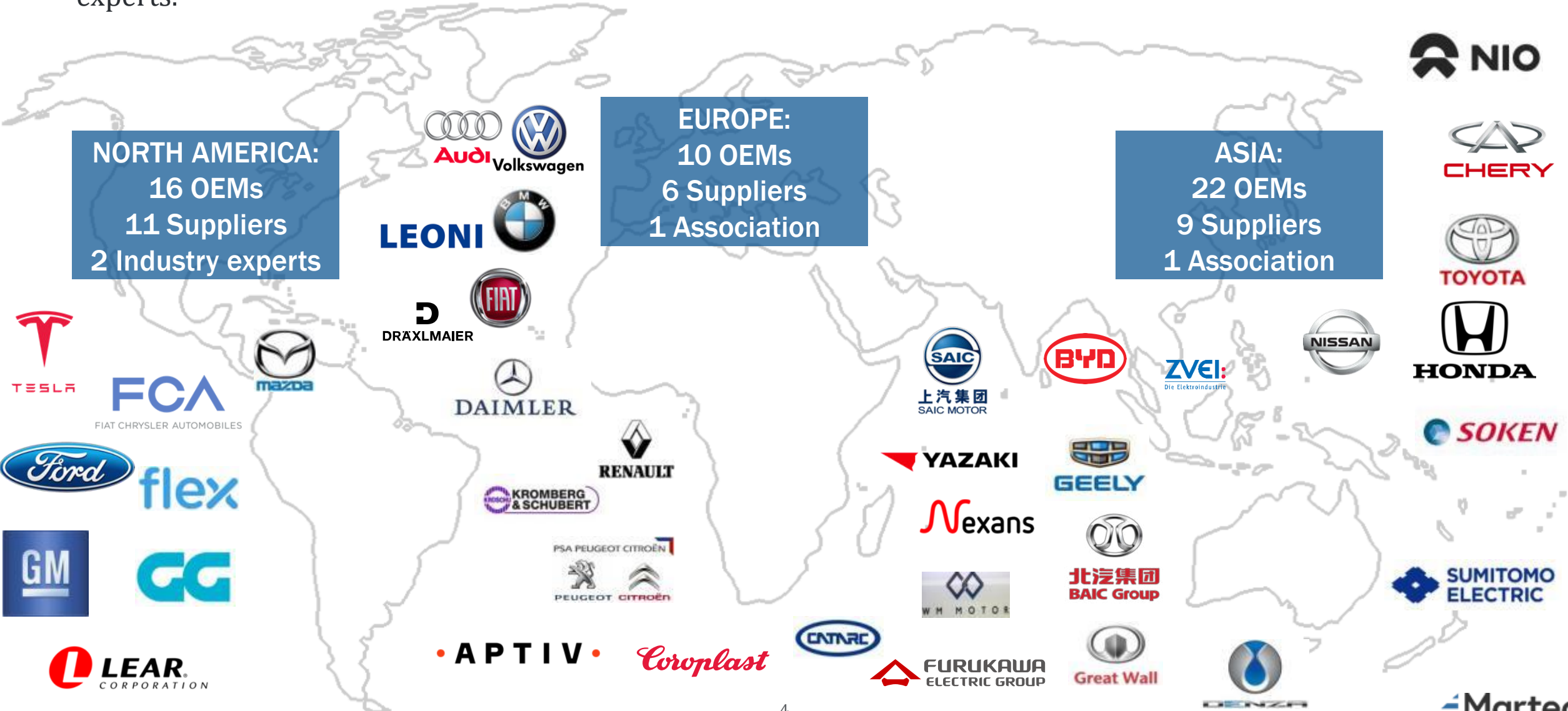
Interview Summary: by Region

Martec conducted over 75 interviews globally with a combination of vehicle OEMs, suppliers and industry experts.

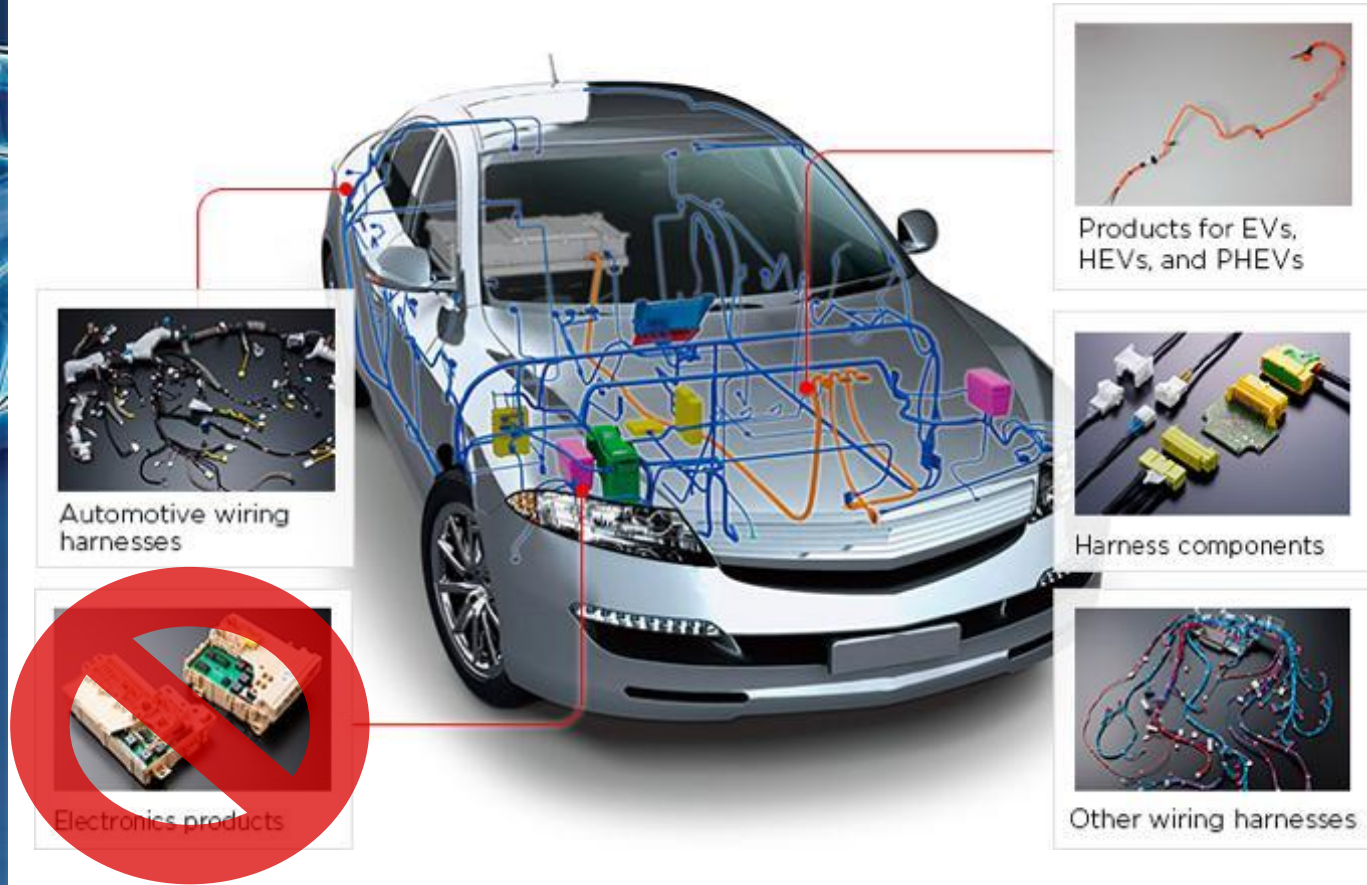
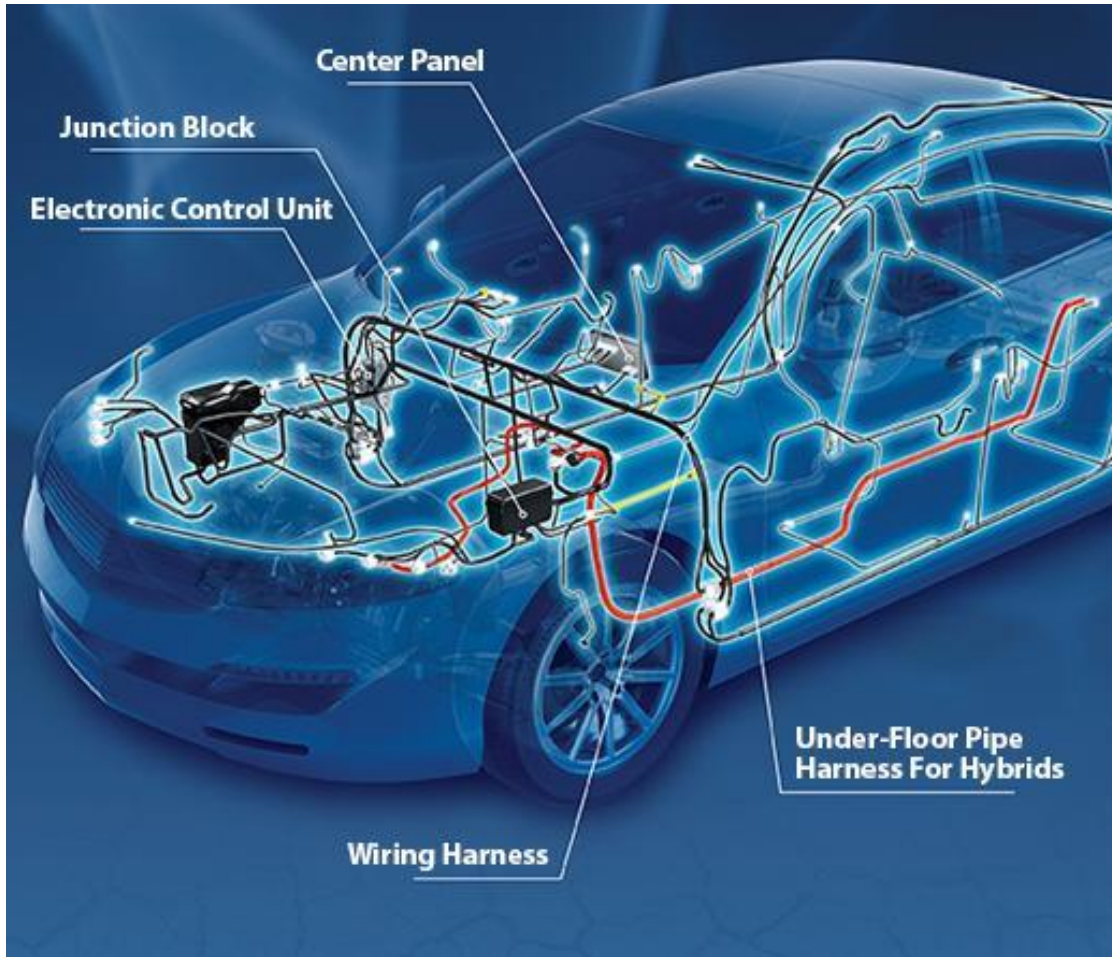
NORTH AMERICA:
16 OEMs
11 Suppliers
2 Industry experts

EUROPE:
10 OEMs
6 Suppliers
1 Association

ASIA:
22 OEMs
9 Suppliers
1 Association



What's included: copper in automotive wire harnesses



Trends Affecting Wire Harnesses

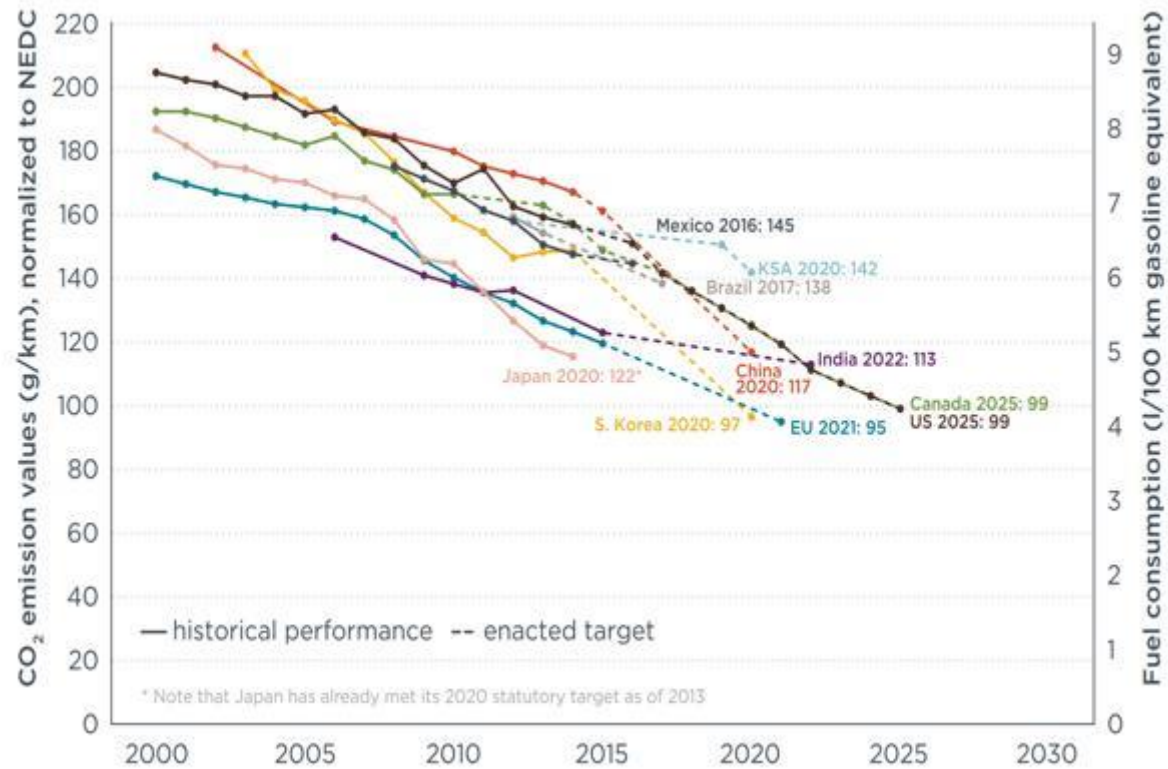
Trend	Details
Miniaturization	<ul style="list-style-type: none">• OEMs pressure Tier 1 suppliers to downsize, and suppliers do the actual design/ work<ul style="list-style-type: none">➢ <i>GM wants more control over design than FCA or Ford</i>➢ <i>FCA alternates between outsourcing design to tier 1 suppliers and bringing it in-house</i>• Puts a limitation on bulkier aluminum wire<ul style="list-style-type: none">➢ <i>0.75mm² and below Copper continues to have an extremely strong position</i>➢ <i>Very minor usage of Aluminum in finer gauges (<0.5mm²) on commercial scale (1 OEM)</i>• Copper alloy conversion still occurring but slower than last reported (Cu-Sn, Cu-Mg, Cu-Ag)• Miniaturization is more popular with OEMs based in Japan & China• Weight reduction is more important than miniaturization to certain Japanese OEMs – they choose to use cost-effective and weight-reducing aluminum alloys instead of more expensive, heavier copper<ul style="list-style-type: none">➢ <i>They use a simple formula to select materials... cost reduction and weight reduction vs. space loss and additional process cost (corrosion treatment)</i>➢ <i>Japanese OEMs are using smaller wires for low voltage environments</i>➢ <i>Some Japanese OEMs intend to miniaturize terminals and connectors and further evaluate Aluminum</i>• Experts say that 50%+ of wire optimization (miniaturization) is now complete
Fuel Economy Regulation	<ul style="list-style-type: none">• Trend toward light weighting vehicles to meet EPA/CAFE standards• OEMs experimenting with aluminum wire because it is much lighter than copper and manage volatility risk

Trends Affecting Wire Harnesses

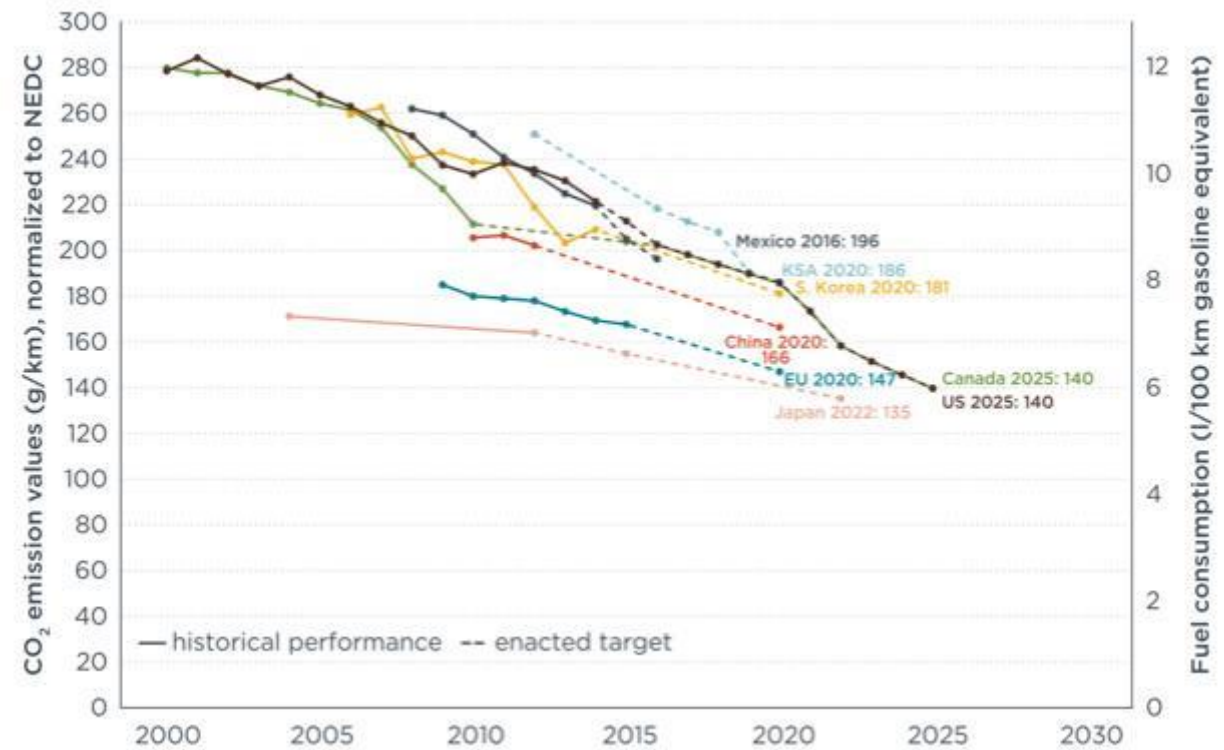
Trend	Details
Demand for Additional Features	<ul style="list-style-type: none"> • Especially on larger SUVs and luxury vehicles • Examples: Heated & cooled seats, heated steering wheel, improved functionality of infotainment, digital IP displays, cooled cupholder, additional powered seating functions, etc.
Electrification, Start-Stop, & Advanced Driver Assistance Systems (ADAS)	<ul style="list-style-type: none"> • Respondents indicate that copper usage <u>will</u> increase rather than decrease due to increased number of wires in the vehicle • AD adoption and EV propulsion systems will continue to grow as these technologies mature and these dual trends will drive more copper usage • This will likely put price pressure on copper, especially if long term demand outstrips supply • Around 2030, more new cars will have these technologies than not (>50% of all production in 2030 will be some form of EV and have some level of AD or Start-Stop functionality on ICE)
Shifting Market Demand	<ul style="list-style-type: none"> • Regional shifts: <ul style="list-style-type: none"> ➢ <i>NA - Consumers are demanding SUVs and trucks more so than sedans (~70/30 split)</i> <ul style="list-style-type: none"> ○ Larger vehicles require more copper than smaller vehicles ➢ <i>China – Continued growth of HEV and BEV due to continued government support</i>
New Ways of Mobility	<ul style="list-style-type: none"> • New ways of mobility (such as car sharing, ride hailing, etc.) may displace the need for a car, or a second car in the garage (some downward production pressure expected by 2030+) <ul style="list-style-type: none"> ➢ <i>If so, this <u>could</u> negatively affect demand for copper in wire harnesses if vehicle production is slowed</i> • However, the mobility service trend will not impact the market significantly for 10+ years

Future CO₂ Standards

Global Passenger Car CO₂ Standards



Global LCV CO₂ Standards

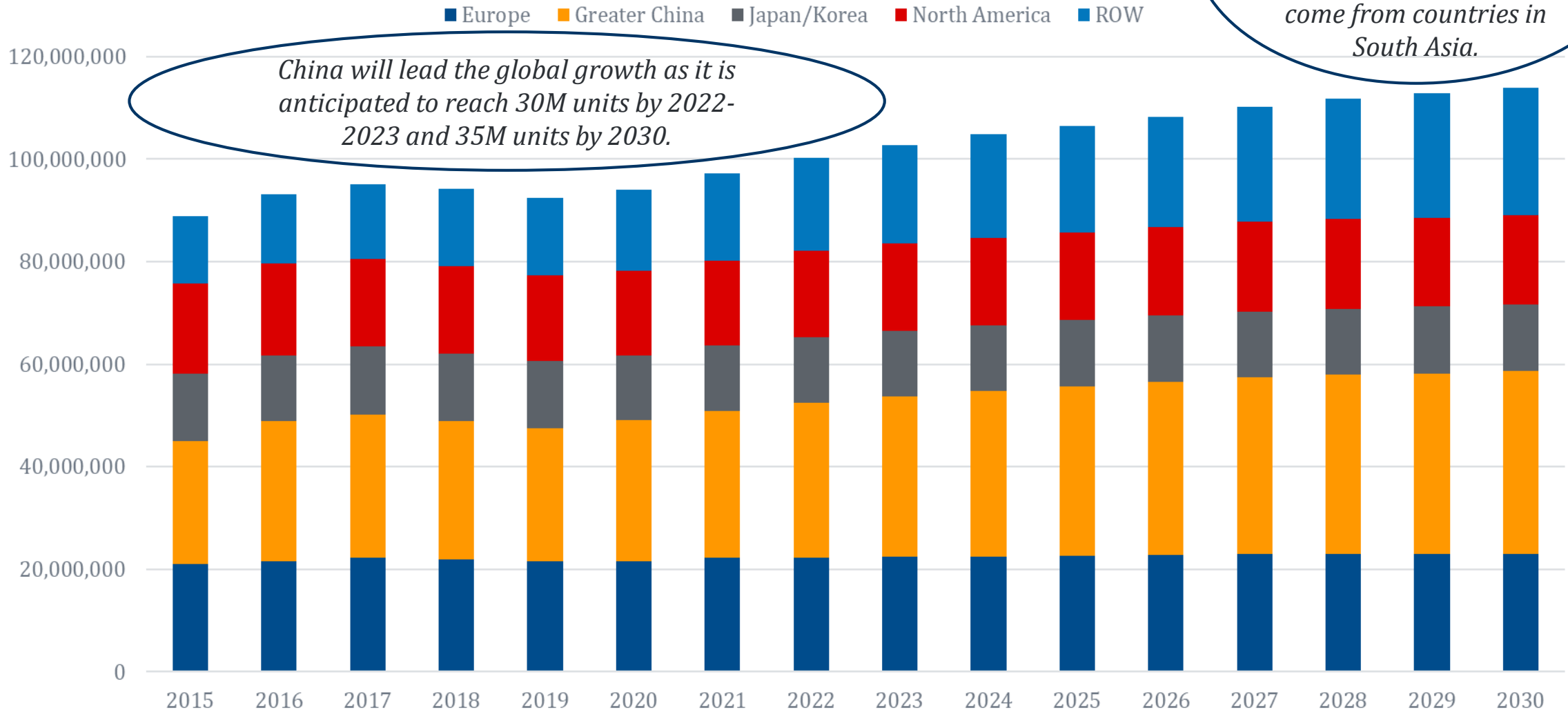


Tighter regulations on emissions will also contribute to more advanced technologies, miniaturization and growth of wire harnesses.

Vehicle Production Forecast, by Region

A majority of the growth over the coming ~10 years comes from developing regions.

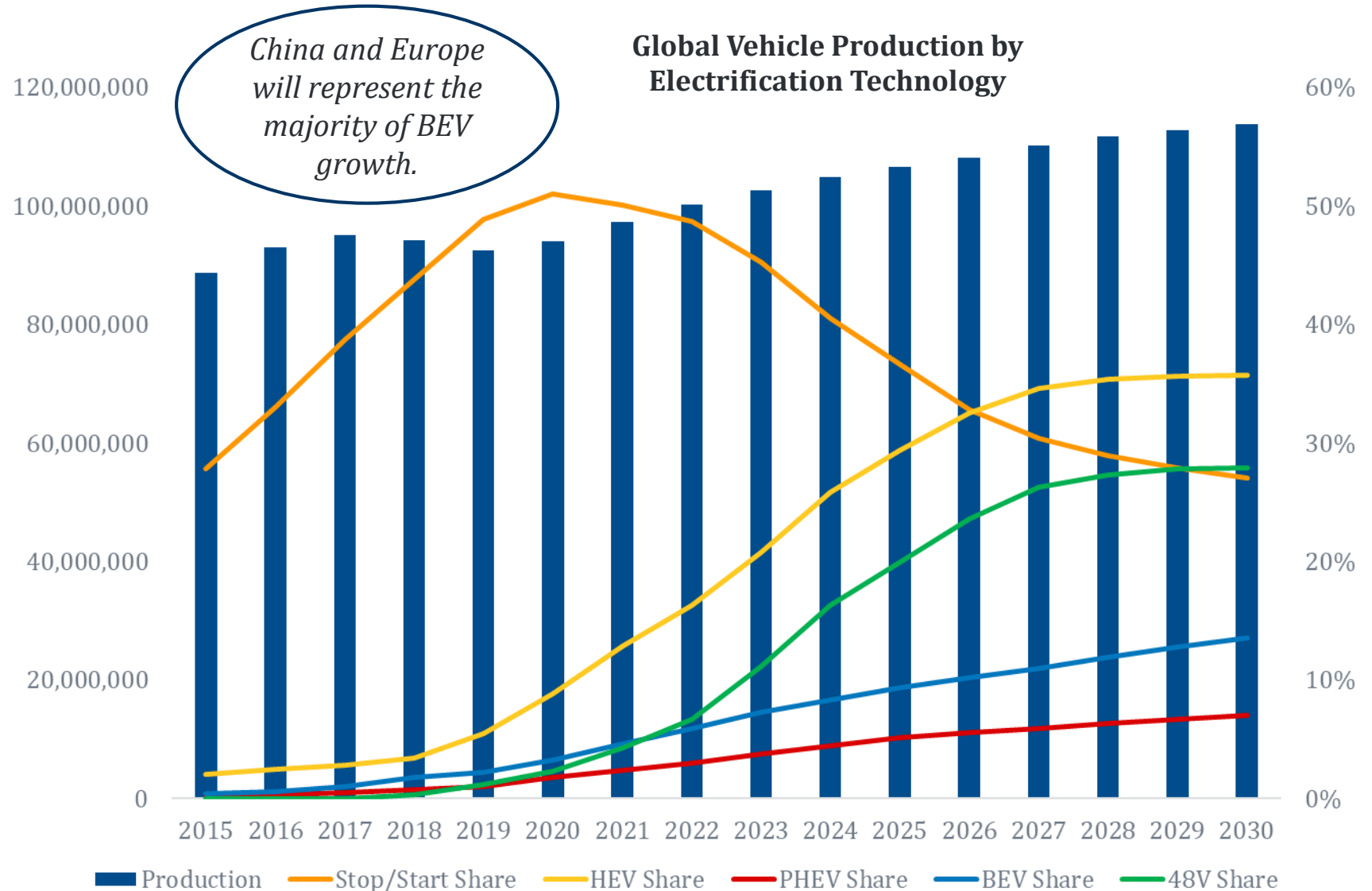
ROW will experience significant growth reaching 20M units by 2025 and 25M by 2030. Most of this growth will come from countries in South Asia.



New Technologies' Penetration, 2015 – 2030

New technologies like electrification, HEV, and BEV grow exponentially over the next 10 years.

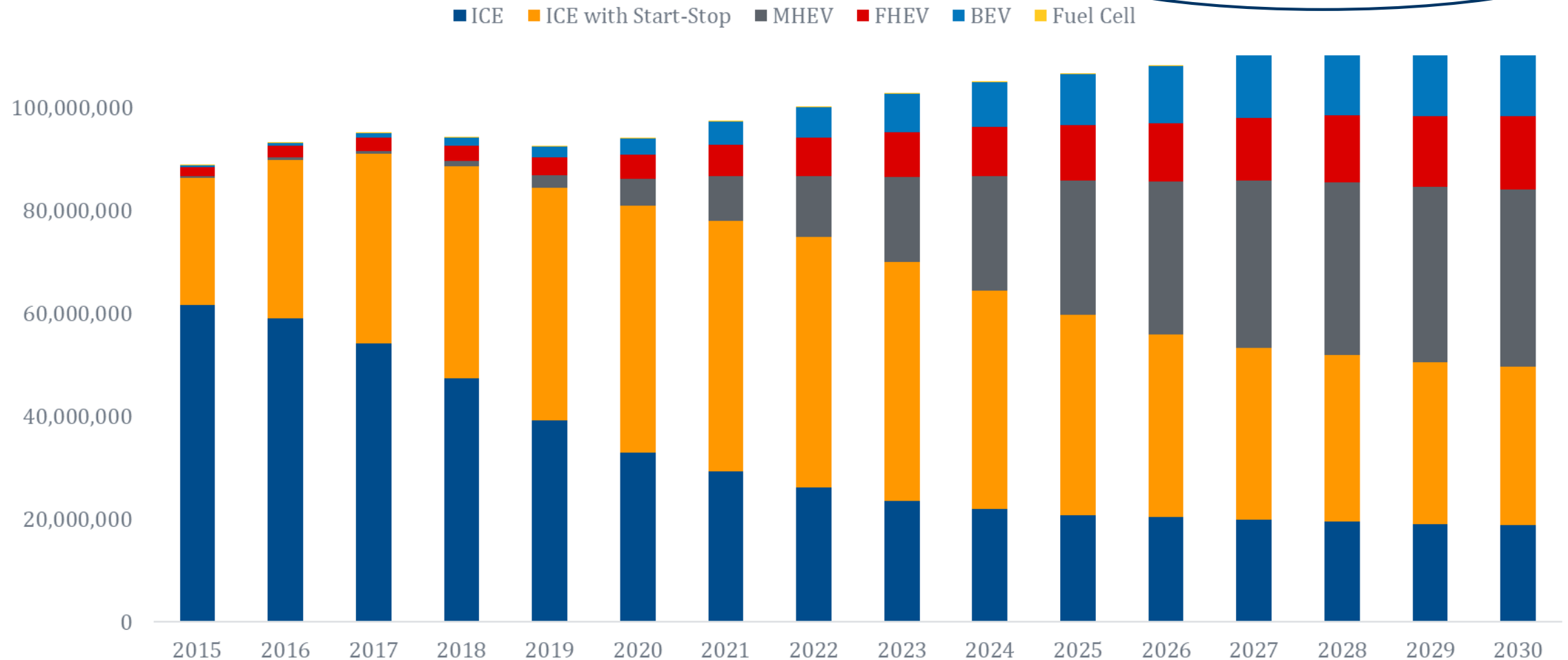
- Stop-Start technology will continue to grow until 2020, where it plateaus, and starts to decline
 - Continued growth of electrification (especially BEV) will impact Start-Stop usage
 - NA region catching up to Europe and Asia in Start-Stop implementation
 - ✓ NA grew from 17% (2016) to 33% (2018)
 - ✓ ROW grew from 38% (2016) to 50% (2018)
- Start-Stop can add ~0.1 – 0.5kg in copper in WH per vehicle



Global Vehicle Production by Propulsion Technology, 2015 – 2030

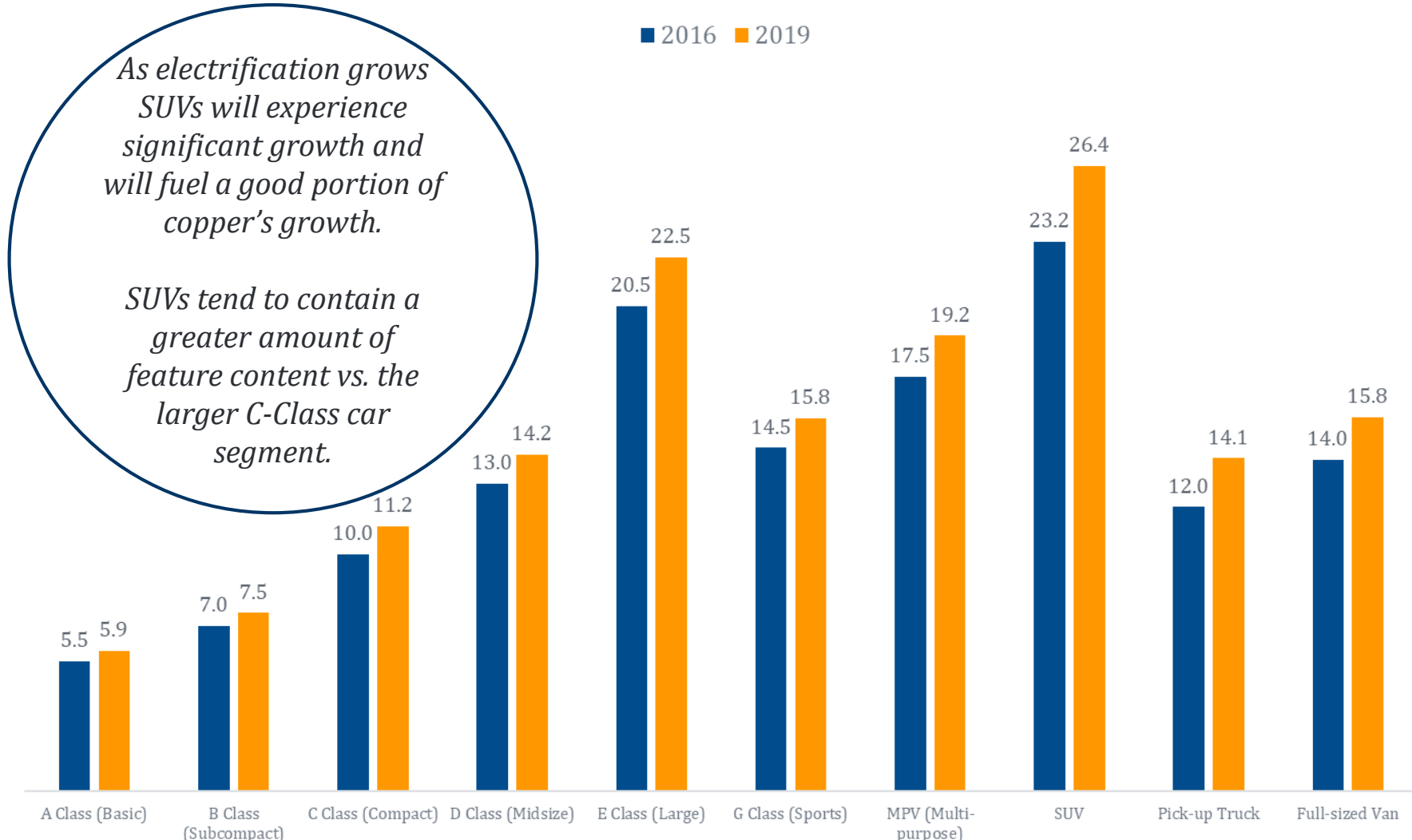
By 2023, more HEV + MHEV + FHEV vehicles will be built than ICE vehicles; by 2027, more electrified vehicles will be built than ICE + ICE with Start-Stop technology.

Hybrids & BEVs combined should surpass ICE & ICE w/ Start-Stop engines by 2027 timeframe.



Larger Vehicles Have Seen the Most Growth in Copper

Average Copper Weight per Vehicle by Segment



As electrification grows SUVs will experience significant growth and will fuel a good portion of copper's growth.

SUVs tend to contain a greater amount of feature content vs. the larger C-Class car segment.

Each vehicle segment is experiencing growth in copper weight from 2016 to 2019.

- New propulsion/electrification technologies as well as additional feature content are adding to copper usage and demand in every vehicle segment
- Pickup truck, SUV, full-sized van, and C-class cars have grown the most from 2016 to 2019, in that order
 - *Each 10%+ growth in copper weight per vehicle*
 - *Larger vehicles require the most wiring*
 - *Typically, larger vehicles tend to be more luxurious with more features requiring more electrical connection*
- Overall average annual growth rate over last 3 years is 3.6%/yr.

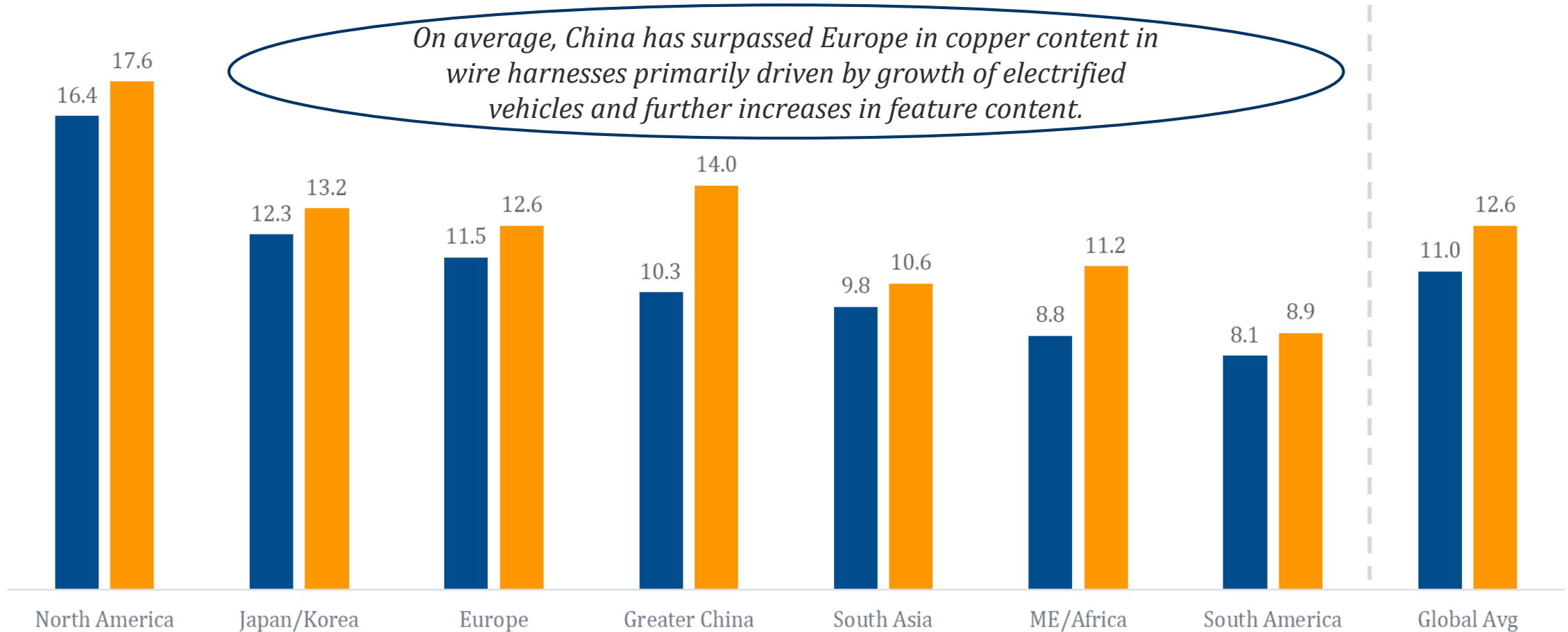
Increased Average Copper Weight

Driven by growth in developing regions (South America, China, and ME/Africa), the growth in penetration of electrified vehicles, and increased features per vehicle.

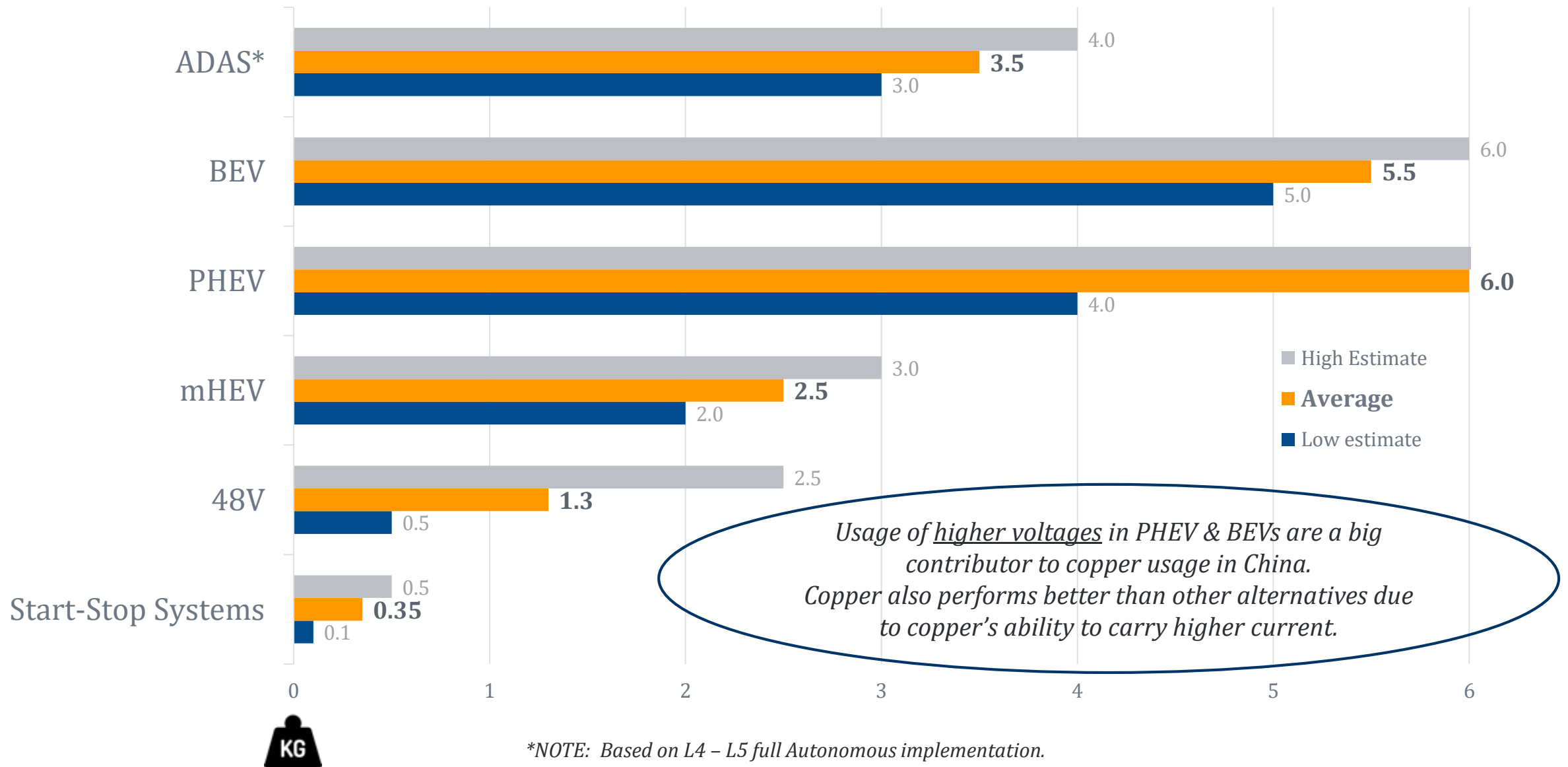
Average Copper Weight (kg) per Vehicle by Region

■ 2016 ■ 2019

On average, China has surpassed Europe in copper content in wire harnesses primarily driven by growth of electrified vehicles and further increases in feature content.



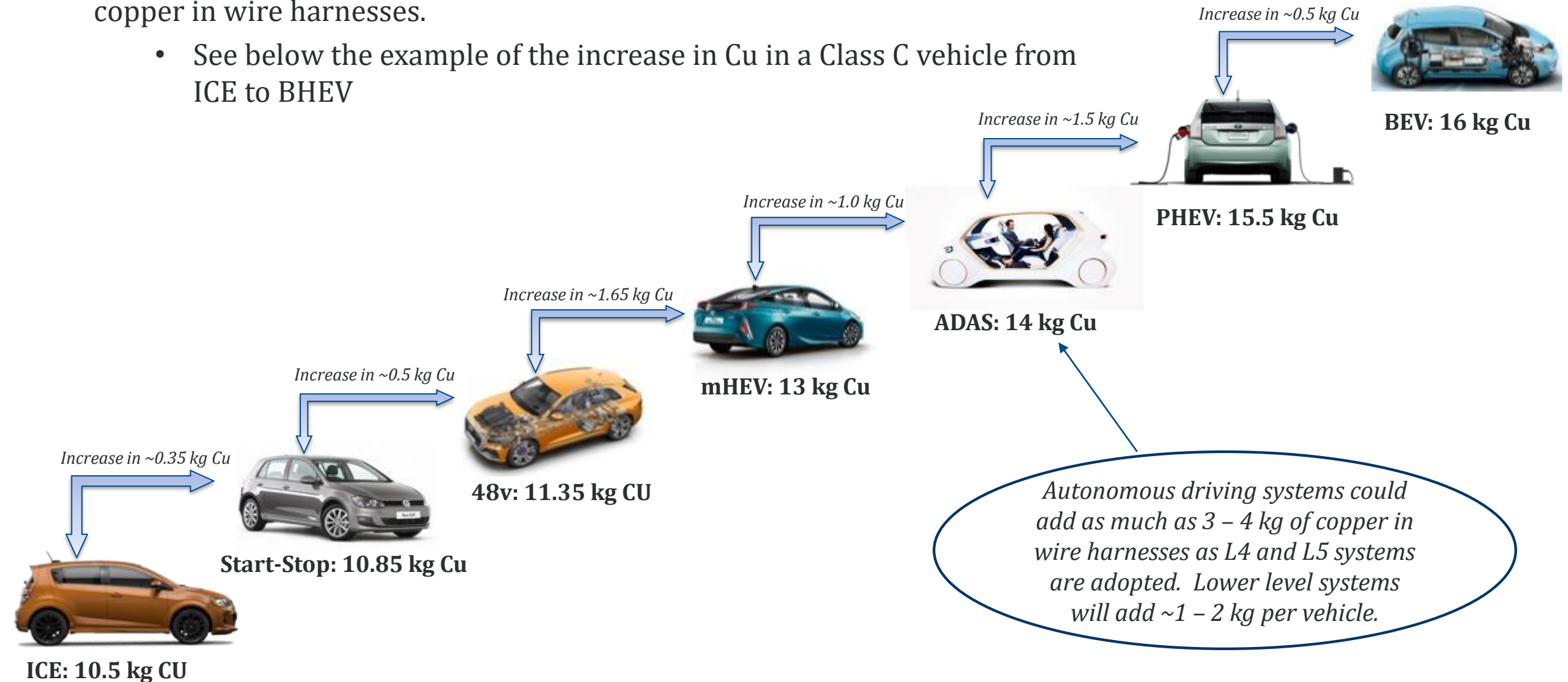
Copper Added in New Technologies (Weight in kg)



New Technologies – Increase Cu in Class C Vehicle

The development of new technologies will continue to drive the demand for copper in wire harnesses.

- See below the example of the increase in Cu in a Class C vehicle from ICE to BEHV



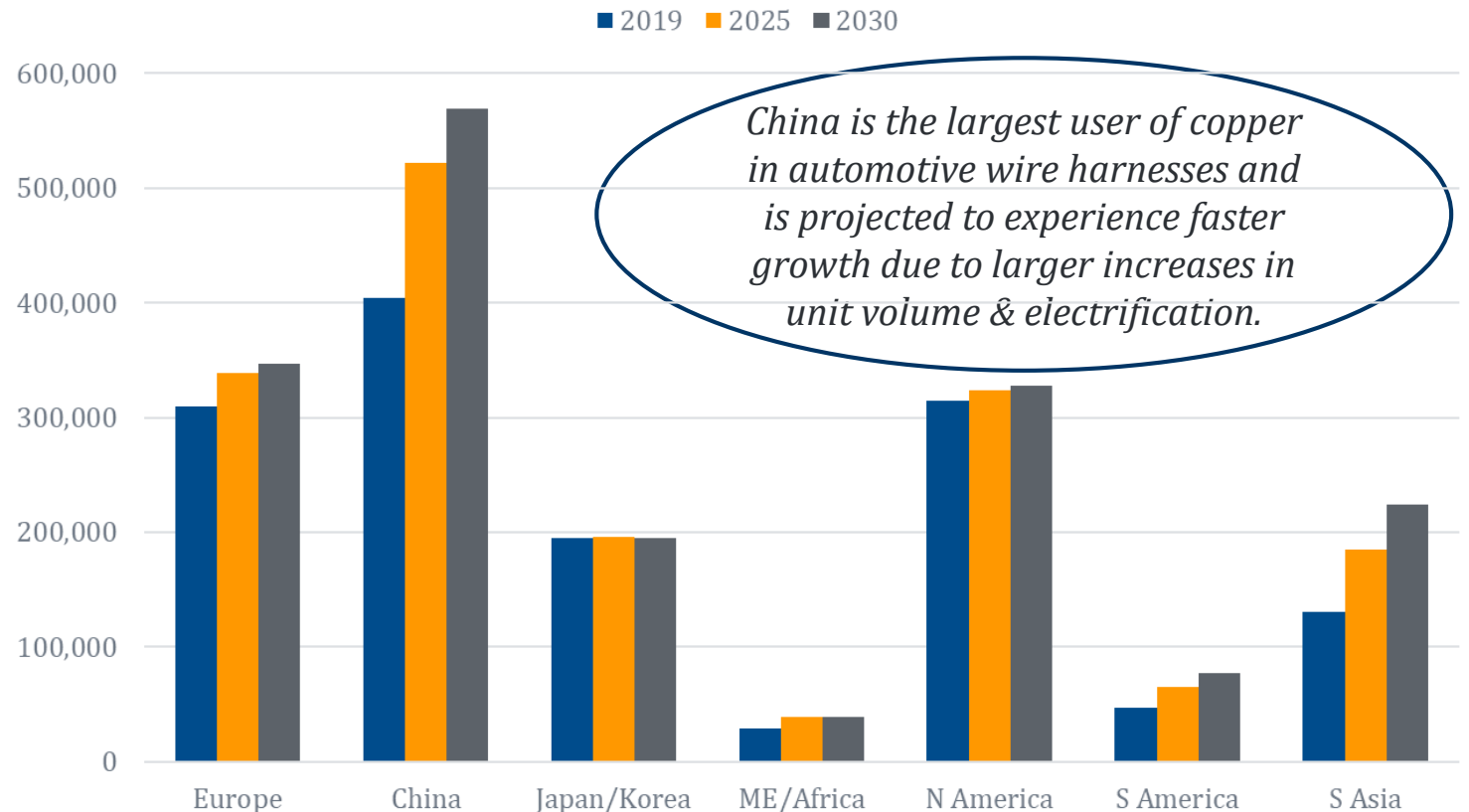
Copper Usage by Region

In 2019, China leads the way followed by North America and Europe.

The copper use estimate by global region is led by China at ~400 kilo tons.

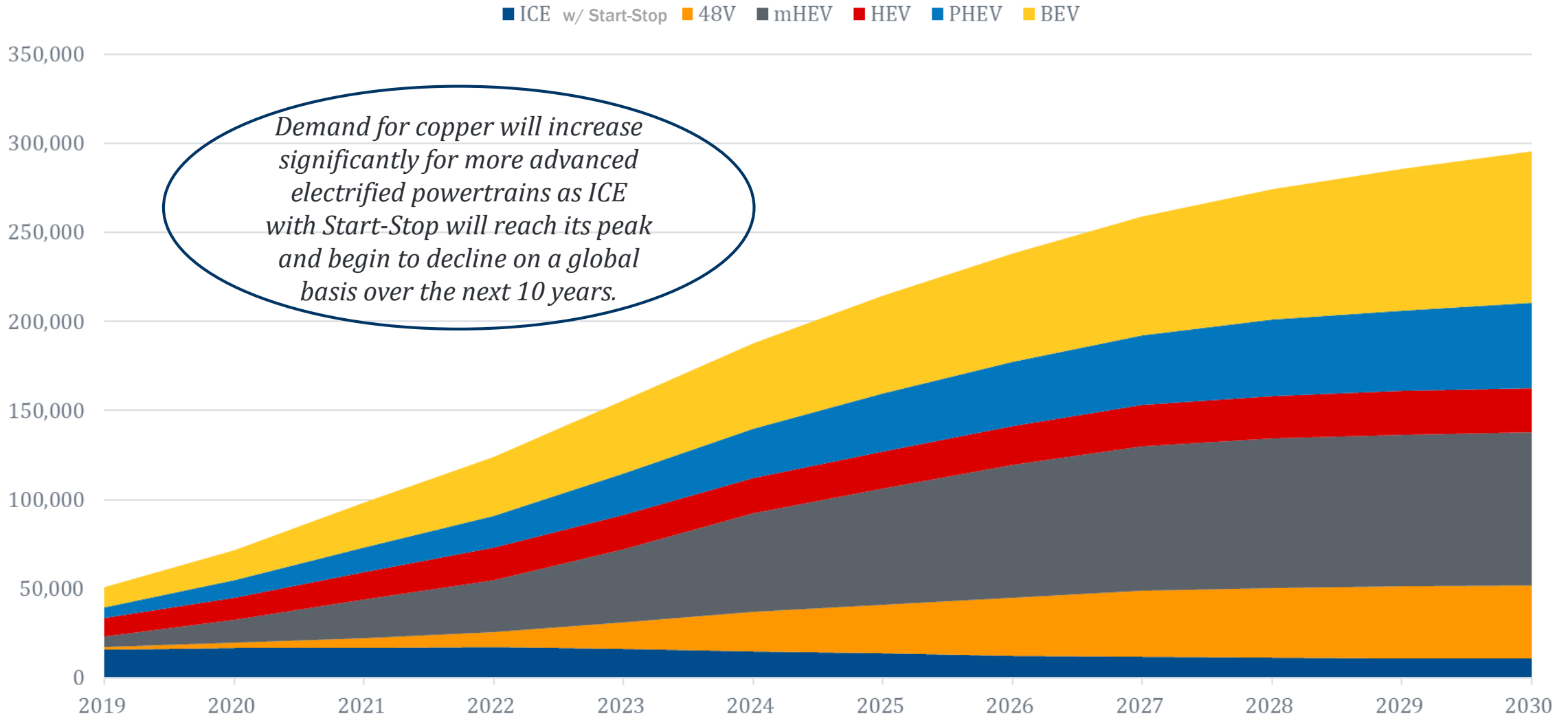
- Increased copper weight is due to:
 - Increased demand for features and functionality in electrified vehicles
 - Increased wiring/ functionality of self-driving vehicles, particularly self-driving
 - Increase in global vehicle production overall
 - Increase in larger vehicle segments
- Copper usage will also experience significant increases in developing regions (South Asia and South America); South Asia is expected to reach 200+ kilo tons by 2030

Annual Estimate of Total Copper Weight (in metric tons) by Region



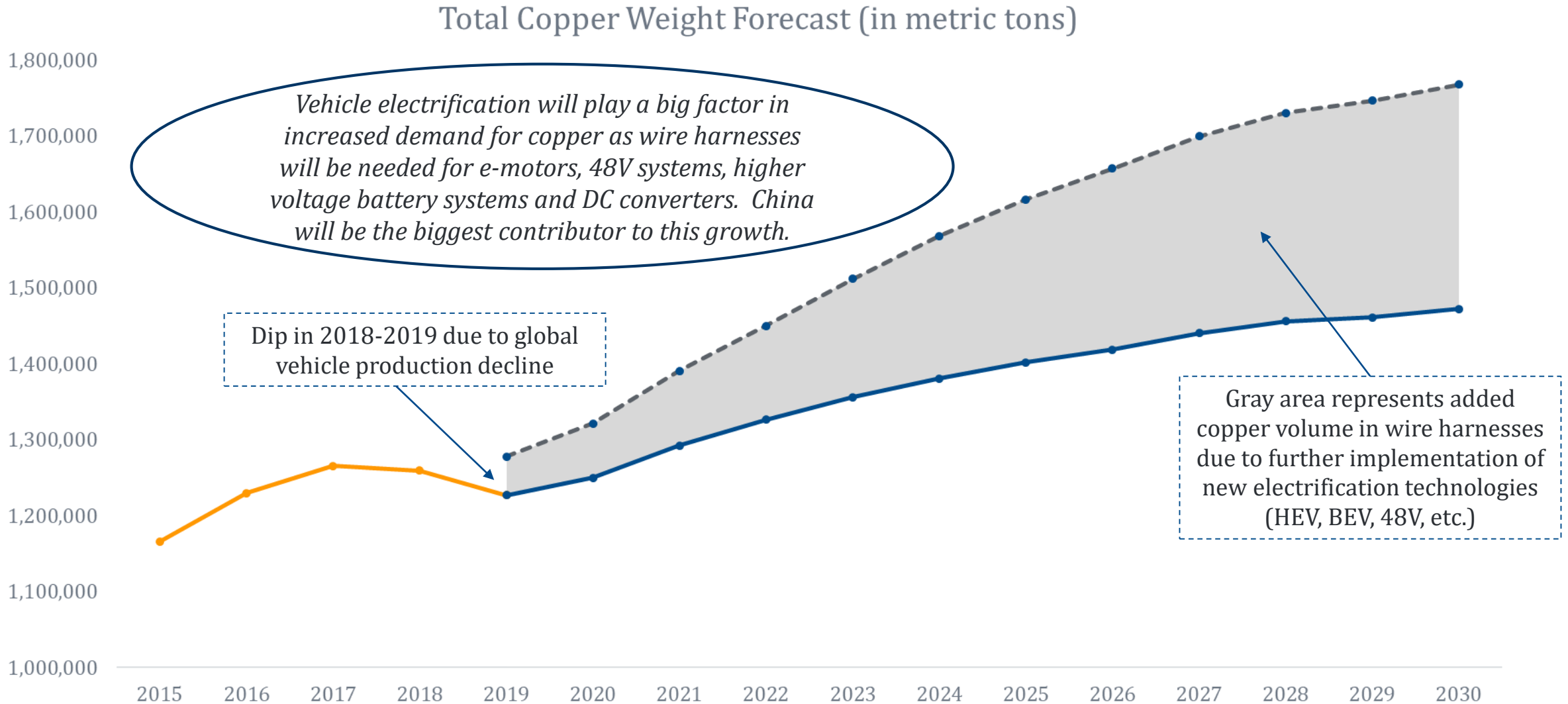
Added Copper Usage by New Technology (in metric tons)

Mild Hybrid and Battery Electric Vehicles will add the most copper weight over the coming 10 years.



Total Copper Usage Forecast (in metric tons)

Copper usage in vehicle wire harnesses will increase from 1.2M in 2019 to ~1.7M in 2030.



Thank you!

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