

# Assessing The North American Supply Chain for Traction Drive Motors

A co-presentation by:

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# Overview of Contents

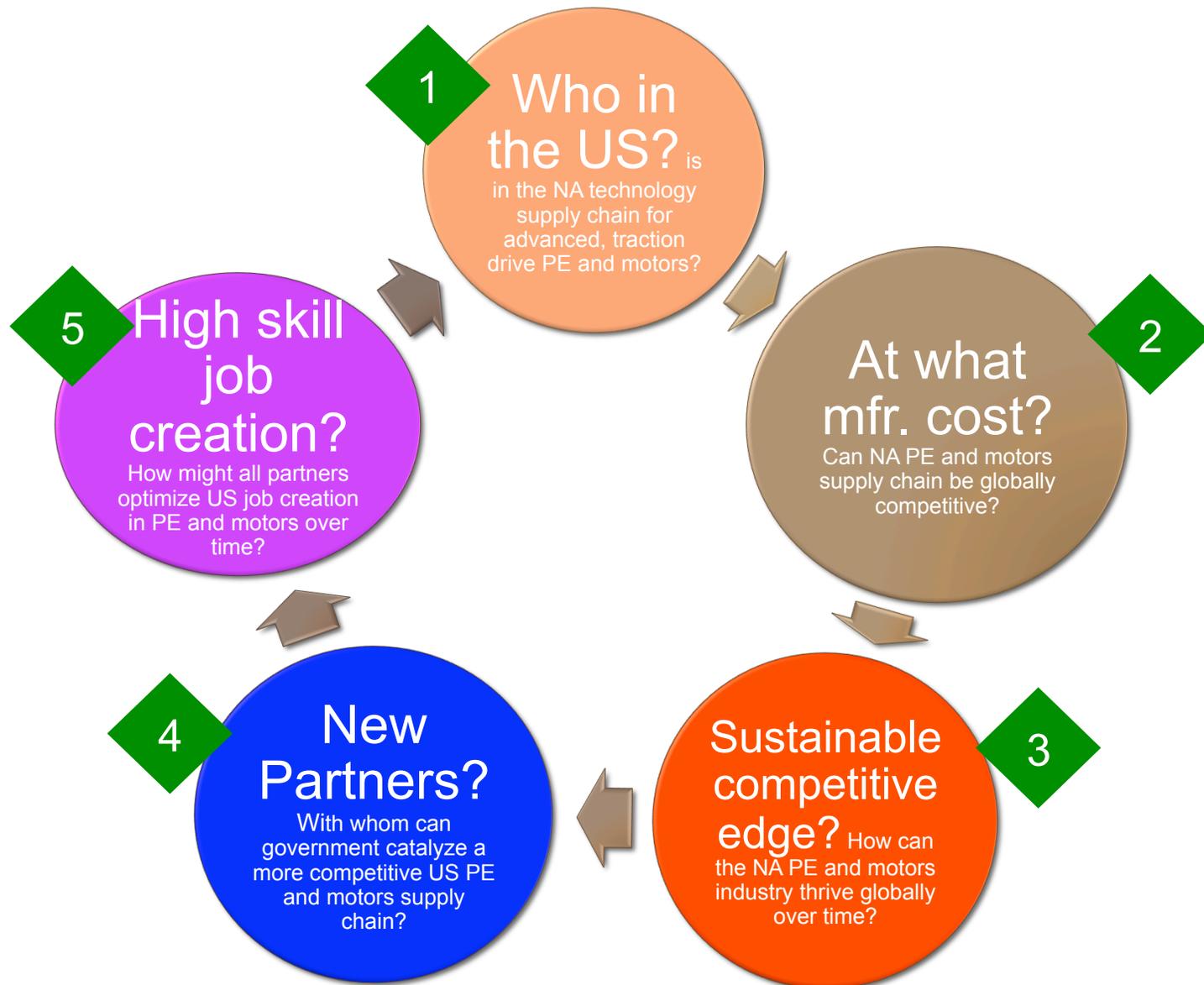
1. Interest in the North American (NA) supply chain for traction drive power electronics (PE) and motors. (Steven Boyd/DOE)
2. Recent research results regarding the NA motors supply chain. (Chris Whaling/SP).
3. Selected next steps and discussion. (Combination).

*Note: Nothing stated in this brief is an official viewpoint of the US Department of Energy or any other official US government entity.*

# Focus of Ongoing Assessment of PE and Motor Supply Chains

- What core competencies are missing from the North American (NA) PE and motor supply chains?
- What might catalyze technology creation and job growth in the NA PE and motor supply chains?
- Is the NA technology supply chain prepared to support a significant increase in demand for advanced traction drive power electronics (PE) and motors? Why or why not?
- What specific R&D support may be helpful to accelerate development of the NA PE and motor supply chains?
- What specific manufacturing support may be helpful to accelerate development of NA PE and motor supply chains?

# Technical Guidance Based on A Process



# Results Based on Integrated Analysis of Private and Public Data

- Private data employed:
  - Synthesis Partners' (SP) archive of 100s of interviews (2012-2015)
  - SP global network of experts.
  - SP network of industry sources (>330 companies).
  - SP company-data and market datasets.
  - Commercially available databases, extended and refined by SP.
- Public data employed:
  - Company annual reports and public filings.
  - Public market studies and literature.
  - Internet search (English, Chinese and Japanese).
  - Conferences and seminars.
  - Federal, state and local datasets.

This work has been underway for five years under DOE-VTO sponsorship.

# From Whom Do We Seek Input?

To-date, SP has executed 200+ in-depth conversations with following types of motor supply chain organizations:

- Top global automotive OEMs
- 50s of global automotive Tier 1s
- 100s of automotive and related Tier 2-4s
- Universities and non-profit research organizations
- DOE National Labs (ORNL, NREL, Argonne, PNNL)
- USCAR Electrical and Electronics Tech Team (EETT)
- DOE and other USG executives
- Other experts

Sample for illustration only:



***Have we spoken to you? If not, please contact [cwhaling@synthesispartners](mailto:cwhaling@synthesispartners) and we will be happy to do so!***

# Selected Organizations Involved in the NA Motor\* Supply Chain

Selection provided for illustrative purposes only.

AC Propulsion Inc.

AK Steel Corp.

Apple, Inc.

Arkansas Power Electronics International, Inc.

Arnold Magnetic Technologies Corp.

BAIC Motor

BorgWarner, Inc.

BYD America Corp.

Continental Automotive Systems US, Inc.

Eurotranciatuura USA LLC

Faraday Future

Fiat Chrysler Automobiles

Ford Motor Co.

GE Global Research

General Motors

Hitachi Automotive Systems America, Inc.

Hitachi Metals North Carolina, Ltd.

JFE Steel America, Inc.

Kienle & Spiess

Magna International of America, Inc.

Molycorp, Inc.

Nippon Steel & Sumitomo Metal USA, Inc.

Nissan North America

Remy International, Inc.

Robert Bosch LLC

Superior Essex

TDK Ferrites Corp.

Tempel Steel Co.

Tesla Motors

Toshiba International Corp.

Toyota Motor, NA

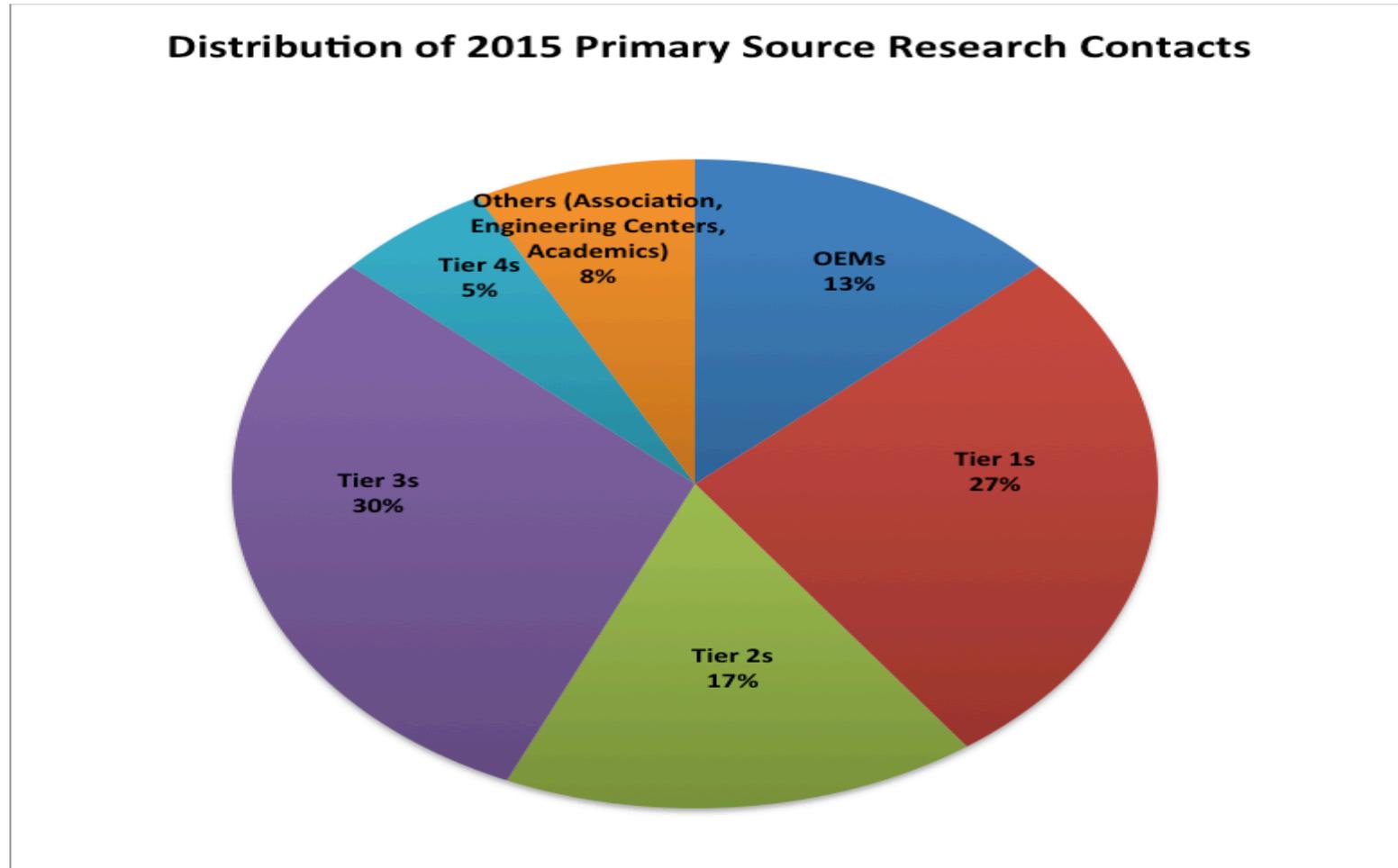
US DOE, Oak Ridge National Laboratory

UQM Technologies Inc.

Wieland Copper Products LLC

\* Focus is on automotive traction drive applications specifically.

# Distribution of Primary Sources



# Analysis of NA Motor Supply Chain Gaps

**Top 10 categories of gaps discovered in the NA motors supply chain from primary source interviews, 2012-2015:\***

- Strategic Investment Planning: 36%
- Situational Awareness: All Types: 18%
- Critical Materials Manufacturing Capacity: 10%
- Training and Engineering Skills: 7%
- Manufacturing Techniques and Tech.: 7%
- Standards Development: 5%
- Coordination and Collaboration: 5%
- Applied R&D: 3%
- Technology Transition Planning: 2%
- Multi-/Single-Industry Collaborative Eng.: 2%

\* Gap categories ranked by percent of all NA motor supply chain gaps raised by primary sources, from 2012 to 2015. Percentages do not add up to 100 because there are several gaps outside the Top 10 that are not included (see report) and rounding. Source: Synthesis Partners, LLC (2015).

# Motors' Gap Analysis Drill-Down

Selected examples of issues raised in top 3 gap categories:

- Selected Strategic Investment Planning Gaps
  - Need to leverage USG resources against fewer challenges; for example, focusing on increasing manufacturing readiness levels.
  - Lack of attention to mid-level producers (i.e., those that work with manufacturing runs in the hundreds to low thousands of units) to achieve flexible manufacturing at low cost.
  - Lack of capability among current NA suppliers, in terms of strategy, skill-sets and investments needed, to go "global" in support of automotive Tier 1s or OEMs.
  - Lack of vision and understanding concerning technology innovation in NA for the purpose of supporting new motor manufacturing in NA (particularly as compared to actions by Japan and China).

# Motors' Gap Analysis Drill-Down (2)

- Selected Situational Awareness Gaps
  - Lack of a NA supply chain database on firms, capabilities, technologies and partnership opportunities.
  - Need for increased transparency regarding criteria for US government contract awards focused on manufacturing know-how, e.g., more knowledge sharing regarding mfg. metrics.
  - Insufficient dialogue and technical information sharing with transplant suppliers (e.g., companies with overseas headquarters which are growing their manufacturing presence in NA).
- Selected Critical Materials Manufacturing Capacity Gaps
  - Si steel (aka, E-steel or electrical steel)
  - Neodymium
  - Magnetic copper
  - Inductor core ferrite materials

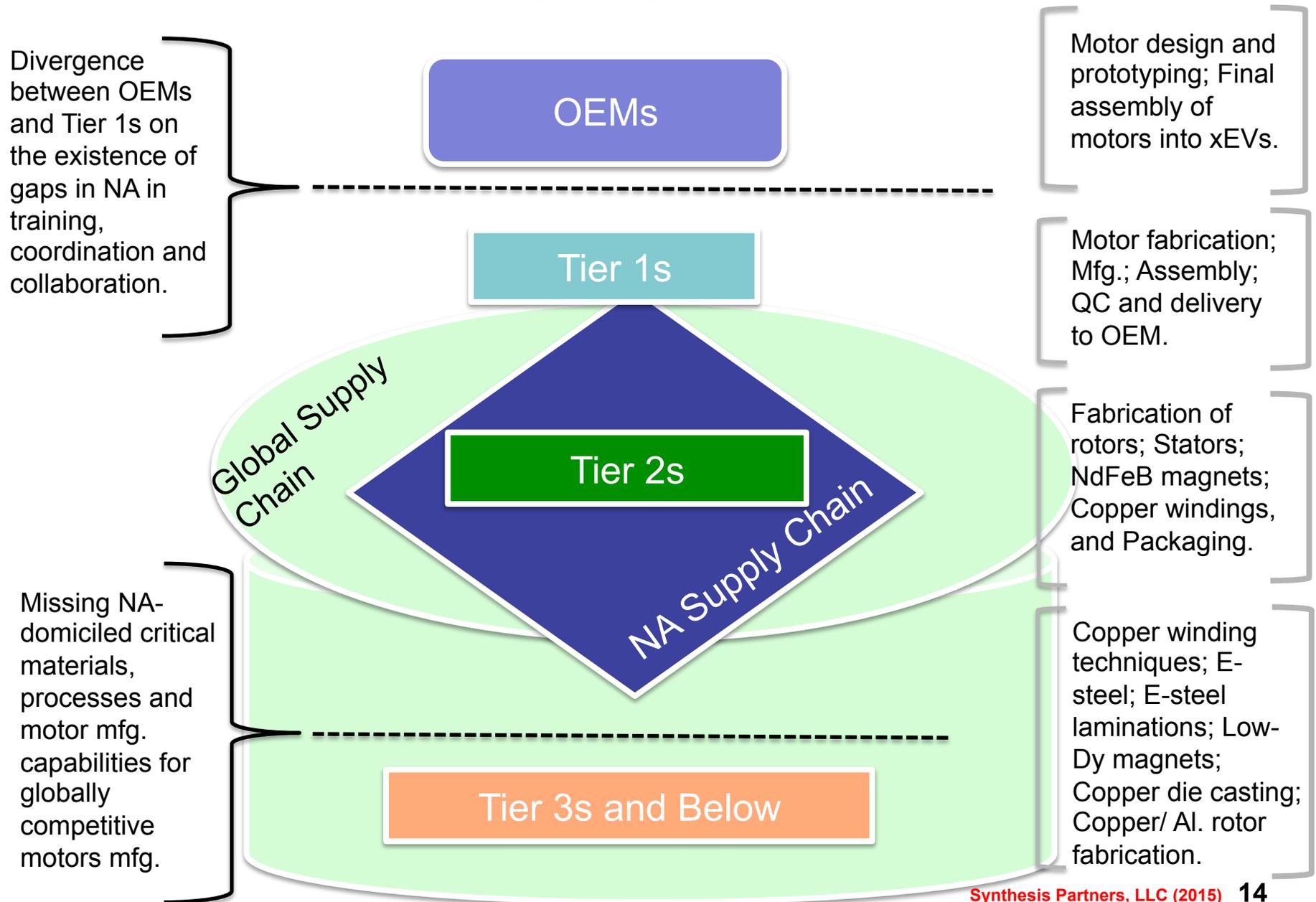
# Critical Materials Highlight

- Silicon Steel (Si- or E-Steel) sourcing is a key issue:
  - Si steel manufacturers see the ~25% per year growth rate in specialty steels anticipated for HEV/EV motors as key growth market.
  - Given the current and expected growth rate in the hybrid and electric vehicle market in the U.S., there may be a shortage of high quality Si-steel 4-5 years out.
  - Si-steel requires a very specific manufacturing pattern/process. One doesn't transition from motor laminated steel to Si-steel in the same plant without an extensive recapitalization effort.
  - It takes 12-24 months to install production equipment for thin steels, so companies need to move to address this potential gap.
  - In addition to US domestic steel manufacturers, both French and Austrian steel producers are looking at this potential market in NA.

# Motors' Gap Analysis Drill-Down (3)

- Several NA motors supply chain gap categories appear to be of less concern (esp. to OEMs), from 2012 to 2015, including:
  - Standards development;
  - Multi- and single-industry collaborative engineering and coordination; and
  - Collaboration between all players.
- Of above-average concern to almost all organization types is critical materials manufacturing capacity. This points to critical single-string dependencies in the core advanced material inputs needed to produce motor magnets, copper windings, and other key components.
- Tier 1 organizations raise twice the number of gaps compared to any other organizational type. And not necessarily the same as OEMs!

# NA Motor Supply Chain is Brittle



# Global Motor Market Rankings

- Top 3 motor producers account for 70% of all production.
- Top 5 motor producers account for 75% of all production.
- The #1 motor supplier (Toyota) has 40% larger market share than the #2 motor supplier (Honda).
- The #2 motor supplier (Honda) has ~9% larger market share than the #3 motor supplier (Toshiba).
- Less than 0.5% separates the market shares of each successive supplier ranked #3 and below. The companies in this part of the supply chain can be seen as “not yet at scale” in the automotive traction drive motor production business.

# Global Motor Market Rankings (2)

- The top NA-based motor producer is Tesla, which is ranked 16<sup>th</sup> globally.
- Tesla Motors' sales are just 30% of the #3 supplier (Toshiba), 9% of the #2 supplier (Honda), and 2% of the #1 producer, Toyota.
- As the cost of motor production is tightly linked to the scale of production, Tesla (and any other company outside the top 3 producers) has a limited ability to significantly reduce the cost of production. The motor suppliers ranked below 16<sup>th</sup> each produced tens of thousands of motors over the five-year period.
- In absolute numbers, the difference in volume between 1<sup>st</sup> ranked Toyota and 2<sup>nd</sup> ranked Honda is significant: 4 million xEVs, or 40% of the market.

# Global Top 20 Motor Suppliers, By Market Share (2011-2015)

RANK	MOTOR SUPPLIER	APPROXIMATE 5-YEAR TOTAL xEVs SUPPLIED (Incl. OEM motor installations only, rounded to nearest 100), From 2011-2015	PERCENT SHARE OF TOTAL xEVs SUPPLIED BY ALL MOTOR SUPPLIERS (Incl. OEM motor installations only), From 2011-2015
1	Toyota	5,267,700	53.25%
2	Honda	1,211,400	12.24%
3	Toshiba	363,800	3.68%
4	Hyundai Mobis	307,500	3.11%
5	Aisin	280,300	2.83%
6	Renault/Nissan	280,000	2.83%
7	Continental	249,600	2.52%
8	Valeo	242,400	2.45%
9	MELCO	207,300	2.10%
10	Hitachi	193,800	1.96%
11	Bosch	169,500	1.71%
12	ZF	160,500	1.62%
13	EM-motive	154,900	1.57%
14	Meidensha	135,000	1.36%
15	BYD	120,000	1.21%
16	Tesla Motors	110,100	1.11%
17	Remy	69,300	0.70%
18	Fuji Machinery	48,900	0.49%
19	AC Propulsion	43,500	0.44%
20	Siemens	35,900	0.36%

# Discussion

Thank you.

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