Assessing The North American Supply Chain for Traction Drive Motors

A co-presentation by:

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This presentation does not contain any proprietary, confidential, or otherwise restricted information
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

1. Who in the US? is in the NA technology supply chain for advanced, traction drive PE and motors?

2. At what mfr. cost? Can NA PE and motors supply chain be globally competitive?

3. Sustainable competitive edge? How can the NA PE and motors industry thrive globally over time?

4. New Partners? With whom can government catalyze a more competitive US PE and motors supply chain?

5. High skill job creation? How might all partners optimize US job creation in PE and motors over time?
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

Have we spoken to you? If not, please contact 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.
Eurotranciatura 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.

Synthesis Partners, LLC (2015)
Distribution of Primary Sources

Distribution of 2015 Primary Source Research Contacts

- Tier 3s: 30%
- Tier 2s: 17%
- Tier 1s: 27%
- Tier 4s: 5%
- Others (Association, Engineering Centers, Academics): 8%
- OEMs: 13%
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).
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

Divergence between OEMs and Tier 1s on the existence of gaps in NA in training, coordination and collaboration.

Missing NA-domiciled critical materials, processes and motor mfg. capabilities for globally competitive motors mfg.

Motor design and prototyping; Final assembly of motors into xEVs.

Motor fabrication; Mfg.; Assembly; QC and delivery to OEM.

Fabrication of rotors; Stators; NdFeB magnets; Copper windings, and Packaging.

Copper winding techniques; E-steel; E-steel laminations; Low-Dy magnets; Copper die casting; Copper/Al. rotor fabrication.

Synthesis Partners, LLC (2015)
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\textsuperscript{th} 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\textsuperscript{th} each produced tens of thousands of motors over the five-year period.

- In absolute numbers, the difference in volume between 1\textsuperscript{st} ranked Toyota and 2\textsuperscript{nd} ranked Honda is significant: 4 million xEVs, or 40\% of the market.

<table>
<thead>
<tr>
<th>RANK</th>
<th>MOTOR SUPPLIER</th>
<th>APPROXIMATE 5-YEAR TOTAL xEVs SUPPLIED (Incl. OEM motor installations only, rounded to nearest 100), From 2011-2015</th>
<th>PERCENT SHARE OF TOTAL xEVs SUPPLIED BY ALL MOTOR SUPPLIERS (Incl. OEM motor installations only), From 2011-2015</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Toyota</td>
<td>5,267,700</td>
<td>53.25%</td>
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<td>2</td>
<td>Honda</td>
<td>1,211,400</td>
<td>12.24%</td>
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<td>3</td>
<td>Toshiba</td>
<td>363,800</td>
<td>3.68%</td>
</tr>
<tr>
<td>4</td>
<td>Hyundai Mobis</td>
<td>307,500</td>
<td>3.11%</td>
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<td>5</td>
<td>Aisin</td>
<td>280,300</td>
<td>2.83%</td>
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<tr>
<td>6</td>
<td>Renault/Nissan</td>
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<tr>
<td>7</td>
<td>Continental</td>
<td>249,600</td>
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<td>8</td>
<td>Valeo</td>
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<td>MELCO</td>
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<td>Hitachi</td>
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<td>Bosch</td>
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<td>20</td>
<td>Siemens</td>
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<td>0.36%</td>
</tr>
</tbody>
</table>
Discussion

Thank you.

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