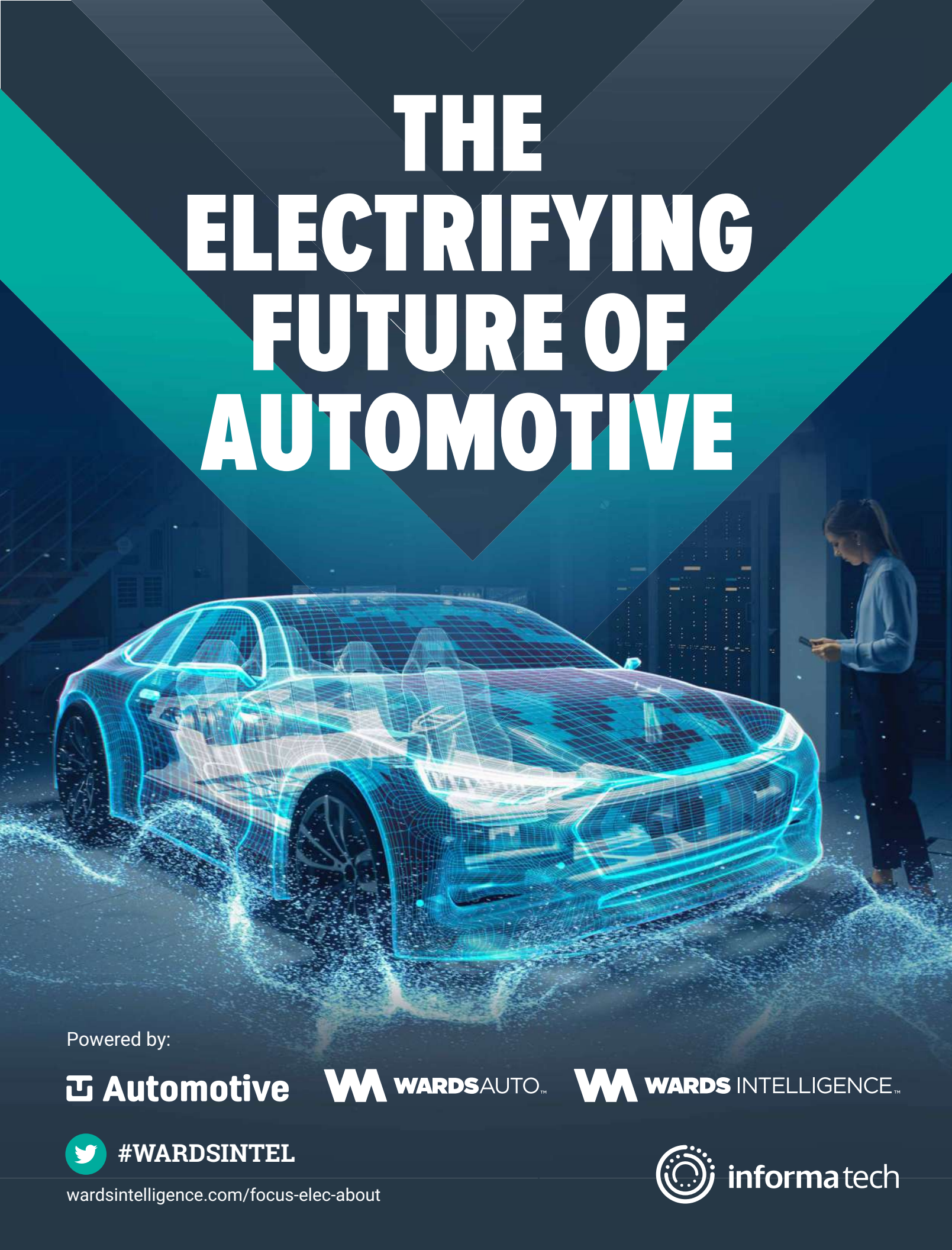
THE ELECTRIFYING FUTURE OF AUTOMOTIVE



Powered by:

Automotive WARDSAUTO WARDS INTELLIGENCE

#WARDSINTEL

wardsintelligence.com/focus-elec-about

informa tech

Are you ready for the Electrifying Future of Automotive?

Here at Informa Tech Automotive Group, we're ready.

Electric Vehicles have ignited a transformational shift in the automotive industry, heightening competition by encouraging market entry for tech firms and start-ups.

Despite the turbulence of 2020, EVs are set to disrupt the marketplace further as we move into 2021.

What does this EV disruption look like? And what do you need to know?

There are still many unanswered questions, such as:

- Following the coronavirus pandemic, do automakers prioritize cheaper ICE vehicles to recoup lost income from the widespread manufacturing plant shutdowns?
- Are EVs the answer to the demands of the growing ethically conscious consumer group?
- How are OEMs evolving to meet the heightened marketplace competition? Are BEVs, PHEVs or HEVs their focus? How is the industry lining up to produce EVs?

Informa Tech Automotive Group's mission is to bring together the entire ecosystem of those in technology and automotive to accelerate the future of our industries. And Electrification is just one of the areas that we predict will have a huge impact on the future.

In this download, you will find unique insight into the future of electrification, including:

- Interview with Robert Kruse, *Senior Vice President of Product Execution* of **Faraday Future**
- Exclusive results from our **Future of Electrification survey**
- An examination of the electric-vehicle market in the 2020s, the state of battery technology and the supply chain needed to support it
- An examination of cutting-edge motor-generator technology and how suppliers are working to meet the growing demands of the global electric-vehicle market.

…and more!

An Interview with...

Faraday Future

Robert Kruse, Senior Vice President of Product Execution of Faraday Future

Robert "Bob" Kruse, Jr. is senior vice president, product execution at Faraday Future. Bob is responsible for leading the entire product development, engineering and manufacturing teams at FF. An automotive industry veteran with over 30 years of experience at GM and other consulting and start-up companies, Bob recently served as CTO at both Karma and Qoros to lead all product development and advanced technology. At Karma, Kruse lead the engineering team that launched Karma's award-winning Revero luxury electric vehicle in 2017, and the company's newly announced 2020 Revero GT.

Bob, you've been the Senior Vice President of Product Execution at Faraday Future for almost a year now. What have you found to be the biggest challenge in bringing the FF 91 prototype to life in that time?

Being at a relatively new company and bringing an all-new product to an already competitive marketplace could be considered an impossible task by many industry insiders. But the FF 91 is a remarkable vehicle, it will set the standard for Global EV execution, performance, and connectivity. We know that FF 91 truly disrupts the status quo. Of course, executing technology with this level of innovation and sophistication is full of challenges; "The bigger the challenge, the bigger the smile on my face!" So, I am smiling a lot right now and relishing the challenge of launching this remarkable vehicle.

Would you say emergent OEMs face more or fewer challenges to legacy automakers in developing prototype electric vehicles?

Both, some things are more difficult for the emerging OEM's, namely the teams are new and there is not a lot of process precedents and background to rely on. On the other hand, many times the big established OEM's have a difficult time innovating, changing course and adopting to new market trends and segments because they are incumbered with past practices and legacy investments.

Our recent Electrification Survey found range anxiety to be a significant contributing factor in consumers opting for ICE vehicles over electric. What strategies have Faraday Future put in place to overcome this?

The FF91 is equipped with one of the industry's largest batteries at 130 kW-hr. This gives our vehicle almost 400 miles on EPA schedule and even more in some day to day driving scenarios. This is more than enough to meet most customers needs. My understanding is 80% of the US population drives 40 miles or less each day. So FF91 customers charge at home or work, while their vehicle would otherwise be parked, and NEVER have to waste time driving to a gas station to purchase energy for their personal transportation needs. Also, we believe in giving the most valuable thing back to our customers – time. Everything about our cutting-edge vehicle and technology was created to make the lives of our users more connected, more engaging, and more effortless. The technologies we incorporate into our vehicle gives them their time back and takes the anxiety out of their lives.

You'll also be presenting on 'Overcoming Range Anxiety to Drive EV's Mainstream' at our FOCUS: Electrification event. How could cohesion and collaboration between the supply chain help to update consumers views on electric vehicle range capabilities?

We have seen adoption rates of Electric Vehicles increasing. I have been developing and working on EV's for over 15 years now. When I first started working on EV's, range anxiety used to be a concern for early consumers. I think today with much more charging infrastructure on a national level, combined with newer EVs pushing close to 400 miles of range this "anxiety" is really not pertinent news like it maybe once was. We are seeing EV range with more than many ICE powered vehicles these days. I believe the convivence acquiring energy for personal transportation at home or work is a strong attribute for EV's.

And what are you most looking forward to about the FOCUS: Electrification event? Are there any particular sessions, or speakers, that stand out to you?

Events like FOCUS Electrification are great opportunities for the best and the brightest on the planet to gather and exchange thought, perspectives and ideas, essentially opening their minds on various important topics that will help to advance the cause of electrification in our industry.
Given your role in overseeing the engineering and manufacturing of the FF 91, are there any key company types you'd be looking to meet at the event?

I have a prodigious global network, that I cultivate and maintain. I appreciate opportunities to meet other thought leaders to explore possibilities. I believe in the advancement of electrification and I always strive to meet and network with those that help advance its cause.

How has COVID-19 affected your business? Are there any plans you've put in place to overcome unforeseen hurdles in the manufacturing process?

COVID-19 is a very unfortunate situation right now but honestly it has been a relatively minor hiccup for us here at FF. Today's collaboration and work technologies have enabled seamless execution no matter where on the planet you happen to be, so utilizing these tools during home quarantine, is a relatively minor step for advanced technology companies like Faraday Future. One benefit that this situation has caused FF is its ability to refine and enhance its remote collaboration capabilities, making us stronger to embrace the challenges of the future.

How do you think the automotive industry will change as a result of COVID-19?

As I said earlier, collaboration internally and with suppliers has actually increased as a result of policies and procedures put in place to deal with mandated quarantines. It has shown us a new way to work, network and collaborate cross-functionally that we never would have undertaken in a non-pandemic scenario.

And finally, is there anything we should be looking out for in 2021 for Faraday Future?

Our first product, the FF91 is both innovative and remarkable. We will bring it to market very soon. I cannot wait to be able to show all of you, with anticipation and excitement your first test drive! 1050 horsepower, with maximum torque at 0 RPM is an experience you will want to drive EVERY day. Coupled with the refinement FF brings, with industry leading connectivity and convenience, is something the whole planet can be excited about experiencing. Once the FF 91 launches, a new standard will be established in the EV space, one we believe will truly disrupt the industry as a whole.

FOCUS: SPEAKERS

Ryan Harty
Head of Connected & Energy Business, American Honda Motor Company

Mark Frohnmayer
President & Founder, Arcimoto

Avinash Rugoobur
President & Chief Strategy Officer, ARRIVAL

Christopher Michelbacher
EV Charging & Infrastructure Manager Audi of America

Gil Castillo
Senior Group Manager – Advanced Vehicle Strategy, Hyundai Motor Company

Stefan Gudmundsson
Chief Innovation Officer, Karma Automotive

Kevin Riddell
Senior Manager, LMC Automotive

Al Bedwell
Director of Global Powertrain, LMC Automotive

Richard D. Braatz
Professor, Massachusetts Institute of Technology

Linda Gaines
Transportation Systems Analyst, Argonne National Laboratory

Marcy Rood
Clean Cities Team Lead – Energy Systems, Argonne National Laboratory

DAIMLER

Senior Representative, Daimler

Ben Burns
Director of Transportation Electrification, DTE Energy

Dane Davis
CTO, Nikola Motor Company

Ganesh Iyer
Managing Director & CIO, NIO

Brian Kelley
Chief Technology Officer, Ohio Turnpike and Infrastructure Commission

Adam Gromis
Public Policy Manager – Sustainable & Environmental Impact, Uber

Steven Boyd
Program Manager – Batteries & Electrification, U.S. Department of Energy

Ryusuke Hayashi
Head of Mobility Business Innovation, Energy & Environment Investment

Chris Moyer
VP & CTO, Exelon

Robert Kruse
Senior Vice President of Product Execution, Faraday Future

Daniel Kok
Global xEV Architect, Ford Motor Company

Beyza Sarioglu
Vice President, Vitesco Technologies

Erin Sunde
Industry Analyst, Wards Intelligence

Bob Gritzinger
Senior Analyst, Wards Intelligence

Christie Schweinsberg
Senior Analyst, Wards Intelligence

Dr. Stefan Hain
Head of Advanced Engineering Semiconductors, ZF Friedrichshafen AG

wardsintelligence.com/focus-elec-about

Agenda Day One

November 18, 2020 | VIRTUAL

WARDS INTELLIGENCE
FOCUS: Electrification

Industry Keynotes – FOCUS: Future of Electrification

10:00am – 11:00am EST

Conference Registration, Platform & Exhibition Opens
Chairperson: *Erin Sunde, Industry Analyst,* ***Wards Intelligence***

11:00am – 11:20am EST

Keynote Presentation: Where Are We Now?
A Wards Intelligence review of the year for electrification.
Speaker: *Christie Schweinsberg, Senior Analyst,* ***Wards Intelligence***

11:30am – 12:00pm EST

Keynote Panel: Overcoming the COVID-19 Setbacks
Following the coronavirus pandemic, the automotive industry faces two options; firstly, do they prioritize cheaper ICE vehicles in an attempt to recoup lost income from the widespread manufacturing plant shutdowns? Secondly, do they prioritize electric vehicles for the growing ethically conscious consumer group following the noticeable reduction in pollution as less vehicles were on the road during national shelter-in-place orders?
Moderator: *Erin Sunde, Industry Analyst,* ***Wards Intelligence***
Panellists: *Kevin Riddell, Senior Manager,* ***LMC Automotive***
Ben Burns, Director of Transportation Electrification, ***DTE Energy***

1:00pm – 1:20pm EST

Keynote Presentation: New Brands for New Products – How OEM's are Branching into Electrification
NIO isn't just an automaker; it provides a complete lifestyle to its customers. Hear from NIO's Managing Director & CIO, Ganesh Iyer, discuss the role of a modern OEM in providing products their customers didn't know they needed. How have NIO solved the charge time dilemma with their power swap stations? Are lifestyle elements such as NIO houses key to attracting and retaining a new generation of car buyers? Will we see autonomy and electrification advance side by side?
Speaker: *Ganesh Iyer,* ***Managing Director & CIO, NIO***

1:30pm – 2:00pm EST

Keynote Panel: What's Next for Electrification?
2020 has been a turbulent year. From the elections to COVID-19 the industry has faced a variety of unforeseen hurdles. What does this mean for EVs? How might their trajectory change? Will we see a push for further electrification developments, or will EVs be side-lined in favour of ICE vehicles? How do the short-term and long-term outlooks differ?
Moderator: *Erin Sunde, Industry Analyst,* ***Wards Intelligence***
Panellists: *Avinash Rugoobur, President & Chief Strategy Officer,* ***ARRIVAL***
Dane Davis, CTO, ***Nikola Motor Company***
Stefan Gudmundsson, Chief Innovation Officer, ***Karma Automotive***

Agenda Day One

November 18, 2020 | VIRTUAL

WARDS INTELLIGENCE
FOCUS: Electrification

2:10pm – 2:35pm EST

Breakout: Meet the Analyst
This is your chance to meet the analyst! Ask your burning questions, discuss their recent work and grow your network.
Erin Sunde, Industry Analyst, ***Wards Intelligence***

Breakout: Meet the Keynote Speakers
This is your chance to meet the keynote speakers! Ask your burning questions, discuss their sessions and grow your network.

Speed Networking
Our virtual speed networking experience is like you would expect at any in-person event. Short 2-minute conversations allow you to instantly grow your network and collaborate with peers. Who will you meet?

Virtual Event Highlights
Take a guided tour of our virtual event – Experience all the technology on offer and discover our standout content sessions.

Solution Room
If you have a question, then post it in our solution room. Any attendees can ask questions and any attendees can answer them. A great way to grow your network and collaborate with peers!

2:35pm – 3:00pm EST

Breakout: Meet the Analyst
This is your chance to meet the analyst! Ask your burning questions, discuss their recent work and grow your network.
Christie Schweinsberg, Senior Analyst, ***Wards Intelligence***

Breakout: Meet the Keynote Speakers
This is your chance to meet the keynote speakers! Ask your burning questions, discuss their sessions and grow your network.

Speed Networking
Our virtual speed networking experience is like you would expect at any in-person event. Short 2-minute conversations allow you to instantly grow your network and collaborate with peers. Who will you meet?

Virtual Event Highlights
Take a guided tour of our virtual event – Experience all the technology on offer and discover our standout content sessions.

Solution Room
If you have a question, then post it in our solution room. Any attendees can ask questions and any attendees can answer them. A great way to grow your network and collaborate with peers!

3:00pm – 4:00pm EST

Virtual Happy Hour ft. Wards Intelligence Electrification Quiz
The Wards Intelligence Electrification Quiz features questions ranging from general knowledge to electrification. Some answers are hidden within the event. Register today for your chance to win the prize!

Close of Day 1

Agenda Day Two

November 19, 2020 | VIRTUAL

WARDS INTELLIGENCE
FOCUS: Electrification

FOCUS: Technology

10:00am – 11:00am EST

Platform & Exhibition Opens
Chairperson: Bob *Gritzinger, Senior Analyst,* ***Wards Intelligence***

11:00am – 11:20am EST

Presentation: Model-Based BMSs for Current and Next-Generation Batteries
Advances in the automotive sector for PHEVs and BEVs along with penetration of renewables for power generation have increased the use of batteries, as energy storage devices, to a great deal.
Venkat Subramanian, *Professor,* **University of Texas, Austin**

11:30am – 12:00pm EST

Panel: Battery Recycling
In pursuit of reduced cost and greater material reclamation, battery recycling technologies are seeing rapid progression. What are the main advantages and disadvantages to pyrometallurgical and hydrometallurgical processes? How will advancements in useable capacity affect the role of second life automotive cells? A discussion of the challenges to transportation and storage of end-of-life lithium-ion battery packs and modules.
Moderator: *Christie Schweinsberg, Senior Analyst,* ***Wards Intelligence***
Panellists: *Linda Gaines, Transportation Systems Analyst,* ***Argonne National Laboratory***
Christopher Michelbacher, EV Charging & Infrastructure Manager, ***Audi of America***

1:00pm – 1:20pm EST

Presentation: Developing Advanced Battery Prediction Techniques with Machine Learning
This presentation will describe advances in machine learning-based techniques for addressing systems problems that arise for lithium-ion batteries. The specific systems problems include the prediction and classification of battery cycle lifetime (aka remaining useful life), the determination of optimal fast-charging protocols, and the identification of fundamental physicochemical expressions for electrochemical kinetics, thermodynamics, and mass transfer from real-time video imaging. This research is in collaboration with researchers at MIT, Stanford, and the Toyota Research Institute.
Richard D. Braatz, Professor, ***Massachusetts Institute of Technology***

1:30pm – 2:00pm EST

Panel: Analysing Power Electronic Developments
Utilizing wide bandgap semiconductors in power electronic components can greatly increase circuit efficiency by creating higher switching frequencies and temperatures. What obstacles must be overcome in order to see GaN & SiC based components take prevalence over traditional silicon?
Moderator: *Bob Gritzinger, Senior Analyst,* ***Wards Intelligence***
Panellists: *Steven Boyd, Program Manager – Batteries & Electrification,* ***U.S. Department of Energy***
Dr. Stefan Hain, Head of Advanced Engineering Semiconductors, ***ZF Friedrichshafen AG***

Agenda Day Two

November 19, 2020 | VIRTUAL

WARDS INTELLIGENCE
FOCUS: Electrification

2:10pm – 2:35pm EST

Breakout: Technological Developments Through Next Generation Power Electronics
Are AlGaN buffer layers the key to increasing GaN reliability while reducing stresses caused by lattice spacing mismatch, or could poly-AIN epitaxy allow for an increased breakdown voltage and lower production cost? Will we see a move to the use of larger substrates in the near future?

Breakout: Ubimobility Technology Showcase
Discover the latest technologies advancing electrification with the Ubimobility Technology Showcase, featuring quickfire presentations from Epicnpoc, iXblue, IRider, Kipsum, Heex Technologies, Lextan and Stampyt.

Meet the Speakers
This is your chance to meet the speakers! Ask your burning questions, discuss their sessions and grow your network.

Virtual Event Highlights
Take a guided tour of our virtual event – Experience all the technology on offer and discover our standout content sessions.

Solution Room
If you have a question, then post it in our solution room. Any attendees can ask questions and any attendees can answer them. A great way to grow your network and collaborate with peers!

2:35pm – 3:00pm EST

Breakout: Ensuring the Safety of Lithium-Ion
How can thermodynamic battery cells and lubricant cooling methods halt the spread of thermal runaway?
How can the inclusion of ultracapacitors relive burst power functions and what effect can this play on specific energy efficiency?

Breakout: Moving Forward with Battery Advancements
As consumers move away from sedans towards CUVs and SUVs, how can OEMs differentiate powertrain architectures in order to deliver new hybrid and BEV opportunities? Hear from Daniel Kok, xEV Architect at Ford, discussing their 4th generation of Li-Ion battery-based powertrain systems. How has the pack developed over time, and what expansions has this enabled?
Daniel Kok, Global xEV Architect, ***Ford Motor Company***

Meet the Speakers
This is your chance to meet the speakers! Ask your burning questions, discuss their sessions and grow your network.

Virtual Event Highlights
Take a guided tour of our virtual event – Experience all the technology on offer and discover our standout content sessions.

Solution Room
If you have a question, then post it in our solution room. Any attendees can ask questions and any attendees can answer them. A great way to grow your network and collaborate with peers!

Close of Day 2

Agenda Day Three

November 20, 2020 | VIRTUAL

WARDS INTELLIGENCE
FOCUS: Electrification

FOCUS: Strategy

10:00am – 11:00am EST

Platform & Exhibition Opens
Chairperson: *Christie Schweinsberg, Senior Analyst,* ***Wards Intelligence***

11:00am – 11:20am EST

FOCUS: Strategy USA

Presentation: Will Regulation Be a Help or Hinderance to EV Adoption?
Following the November elections, how should the electric vehicle ecosystem best react to potential regulation changes? What can we do to avoid the fallout from turbulent external environments in the future?
Erin Sunde, Industry Analyst, ***Wards Intelligence***

FOCUS: Strategy Europe

Presentation: Learning from the Norwegians – Electrification Implementation
From Government incentivization as early as the 90's to hydropower prevalence, Norway has gained a reputation for being an EV leader. Today electric vehicles are the norm, accounting for 60% of new vehicles. How did Norway gain the top spot for EV usage and what can international OEMs learn from their strategies?
Al Bedwell, Director of Global Powertrain, ***LMC Automotive***

FOCUS: Strategy Asia

Presentation: Electrification Innovation – Following the Money
The energy and environment sectors continue to facilitate electric vehicle prevalence, and start-ups are the key to innovation. Where are the investments going in this area? Are EVs the only element of electrified mobility to look out for, or are new robot and drone industries emerging? How can charging infrastructure become part of a holistic road and parking system?
Ryusuke Hayashi, Head of Mobility Business Innovation, ***Energy & Environment Investment***

11:30am – 12:00pm EST

Panel: The Global Roadmap to Electrification
COVID-19, government incentives, charging infrastructure, energy sources, mining & manufacturing, import vs export; How are countries around the globe facilitating EV developments? What can we learn from early adopter's trial and error? Where is the industry predicted to inflate, and where is it expected to stagnate?
Moderator: *Christie Schweinsberg, Senior Analyst,* ***Wards Intelligence***
Panellists: *Gil Castillo, Senior Group Manager – Advanced Vehicle Strategy,* ***Hyundai Motor Company***
Ryan Harty, Head of Connected & Energy Business, ***American Honda Motor Company***

Agenda Day Three

November 20, 2020 | VIRTUAL

WARDS INTELLIGENCE
FOCUS: Electrification

1:00pm – 1:20pm EST

Presentation: Overcoming Range Anxiety to Drive EV's Mainstream
Findings from an Informa Tech Automotive Group study show range anxiety to be a significant contributing factor in consumers purchasing ICE vehicles rather than EVs, but opinions on vehicle range can be considerably outdated. Should OEMs prioritize hybrid vehicles as the solution to overcoming range anxiety? How can utilities aid automakers in furthering the marketing message on vehicle range?
Robert Kruse, Senior Vice President of Product Execution, ***Faraday Future***

Presentation: LEVs Driving the Future City
Cities and roads were not built for the vehicles of the 21st century. LEVs are being implemented as a solution to city congestion. What more needs to be done to ensure the seamless integration of LEVs into city infrastructure, and how can public-private partnerships help?
Mark Frohnmayer, President & Founder, ***Arcimoto***

2:10pm – 2:35pm EST

Panel: Building out Charging Infrastructure for the Electric Vehicle
Could the implementation of network organized subscription services prevent the 'claiming' of charge points and increase the accessibility of charging solutions? How could developmental technologies be used to prevent the underutilization of capital intensive DCFCs? Could these be the answer to expanding fleet charging infrastructure?
Moderator: *Christie Schweinsberg, Senior Analyst,* ***Wards Intelligence***
Panellists: *Marcy Rood, Clean Cities Team Lead – Energy Systems,* ***Argonne National Laboratory***
Ganesh Iyer, Managing Director & CIO, ***NIO***
Chris Moyer, VP & CTO, ***Exelon***

Breakout: Creating a Sustainable Electric Vehicle Supply Chain
As a direct result of significantly fewer necessary moving parts, BEVs are far simpler to build than ICE vehicles. What impact will this have on the supply chain? How can both small and large industry players adopt different capabilities in order to maintain their position within the chain?
Beyza Sarioglu, Vice President, ***Vitesco Technologies***

Breakout: The End of Chinese Government Incentivization – What's Next?
5 years ago, the Chinese Government announced their plans to terminate electric vehicle subsidies in 2020, before extending the time limit to 2022. Is this reluctancy to completely eliminate tax breaks a sign of their effectiveness? Is the subsidy deadline likely to be reextended further? What does this mean for the future internal EV market in China?

Meet the Speakers
This is your chance to meet the speakers! Ask your burning questions, discuss their sessions and grow your network.

Agenda Day Three

November 20, 2020 | VIRTUAL

WARDS INTELLIGENCE
FOCUS: Electrification

2:10pm – 2:35pm EST

Virtual Event Highlights
Take a guided tour of our virtual event – Experience all the technology on offer and discover our standout content sessions.

Solution Room
If you have a question, then post it in our solution room. Any attendees can ask questions and any attendees can answer them. A great way to grow your network and collaborate with peers!

2:35pm – 3:00pm EST

Breakout: Ethical Manufacturing & Mining
Many consumers opt for electric over internal combustion vehicles on ethical grounds. However, the cobalt for lithium-ion batteries is often unethically sourced through child labour in the dangerous mines of the Democratic Republic of the Congo. What can OEMS and battery makers do to ensure the reputability of their supply chains?

Breakout: The Role of Public-Private Partnerships in Charging Infrastructure
Hear from Brian Kelley, Chief Technology Officer at the Ohio Turnpike and Infrastructure Commission, discussing their recent implementation of in-road charging. How have their cooled-cable systems relieved range anxiety? To what extent will be see the role of public-private partnerships develop in building out amalgamated charging infrastructure?
Brian Kelley, Chief Technology Officer, ***Ohio Turnpike and Infrastructure Commission***

Meet the Speakers
This is your chance to meet the speakers! Ask your burning questions, discuss their sessions and grow your network.

Virtual Event Highlights
Take a guided tour of our virtual event – Experience all the technology on offer and discover our standout content sessions.

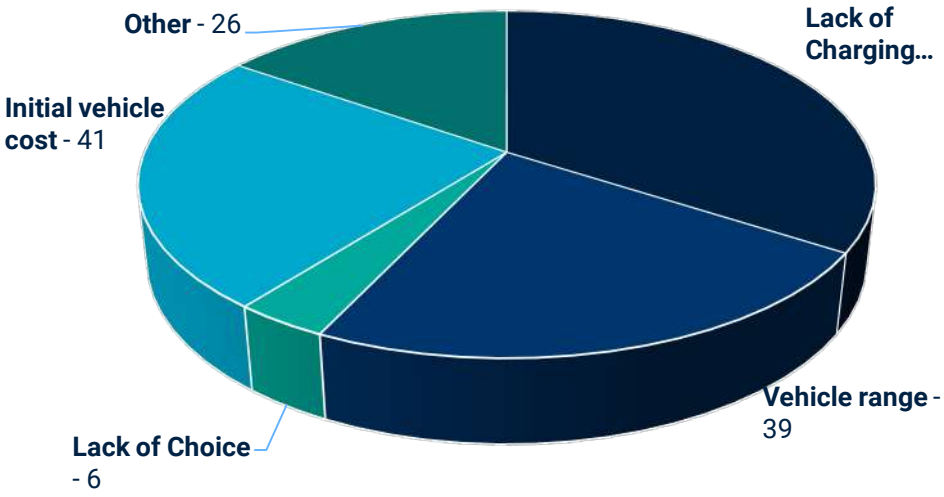
Solution Room
If you have a question, then post it in our solution room. Any attendees can ask questions and any attendees can answer them. A great way to grow your network and collaborate with peers!

Close of Wards Intelligence FOCUS: Electrification 2020

The State of the Electric Vehicle Market in North America

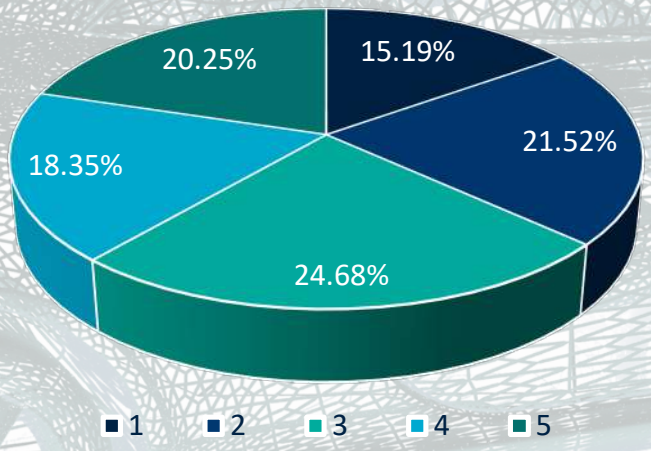
In May 2020 the Informa Tech Automotive Group set out to uncover the state of the electric vehicle market in North America. From potential regulation changes to COVID-19 uncertainties to supply chain transformations, the market has experienced a turbulent year and that uncertainty doesn't look set to end anytime soon. We've compacted our survey findings into a summary below to help you best prepare for the year ahead.

In your view, which is the biggest setback to widespread US EV adoption?

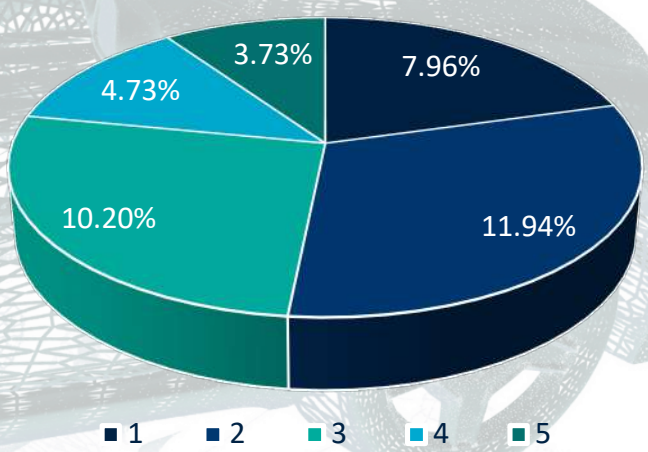


It's no surprise that the biggest setback for widespread EV adoption in the USA is the lack of charging infrastructure, with 1/3rdof respondents confirming so. But this is by no means the only obstruction to personal electric vehicle ownership. Just under half of respondents (47%) cited range anxiety or initial vehicle cost as fundamental impediments to adoption. It appears that despite significant battery developments, consumers are still hesitant to rely solely on a BEV. Perhaps that's why 2/3rdof our audience also agreed that hybrid vehicles provide the best solution for overcoming range anxiety issues. Consumers are hesitant to change, looking for reassurance that the vehicle can still be powered by the internal combustion engine that they are used to.

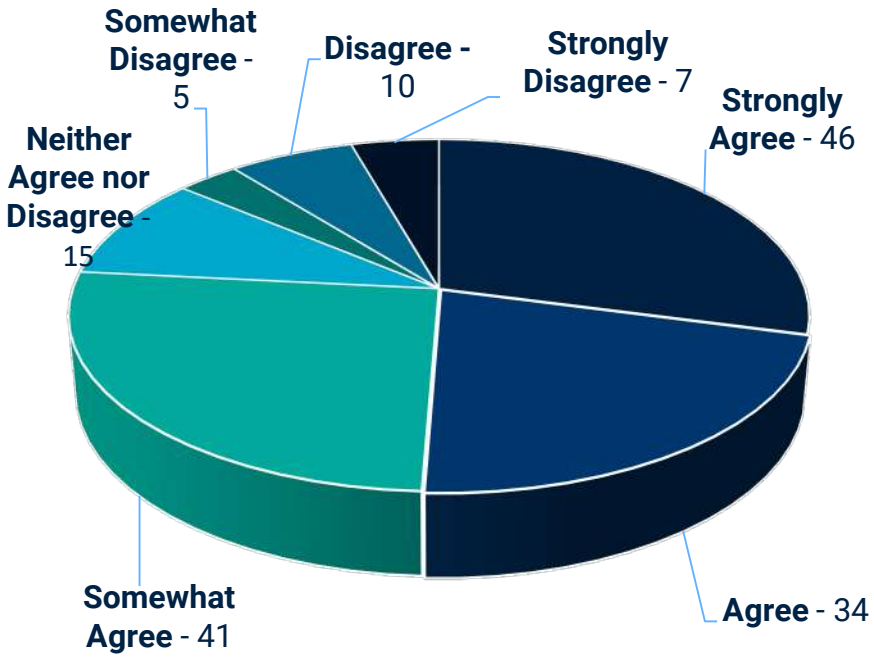
From 1 (highest) to 5 (lowest), how great do you see the impact of COVID-19 being on EV adoption over the next 2 years?



From 1 (highest) to 5 (lowest), how great do you see the impact of US regulation & legislation being on EV adoption over the next 4 years?



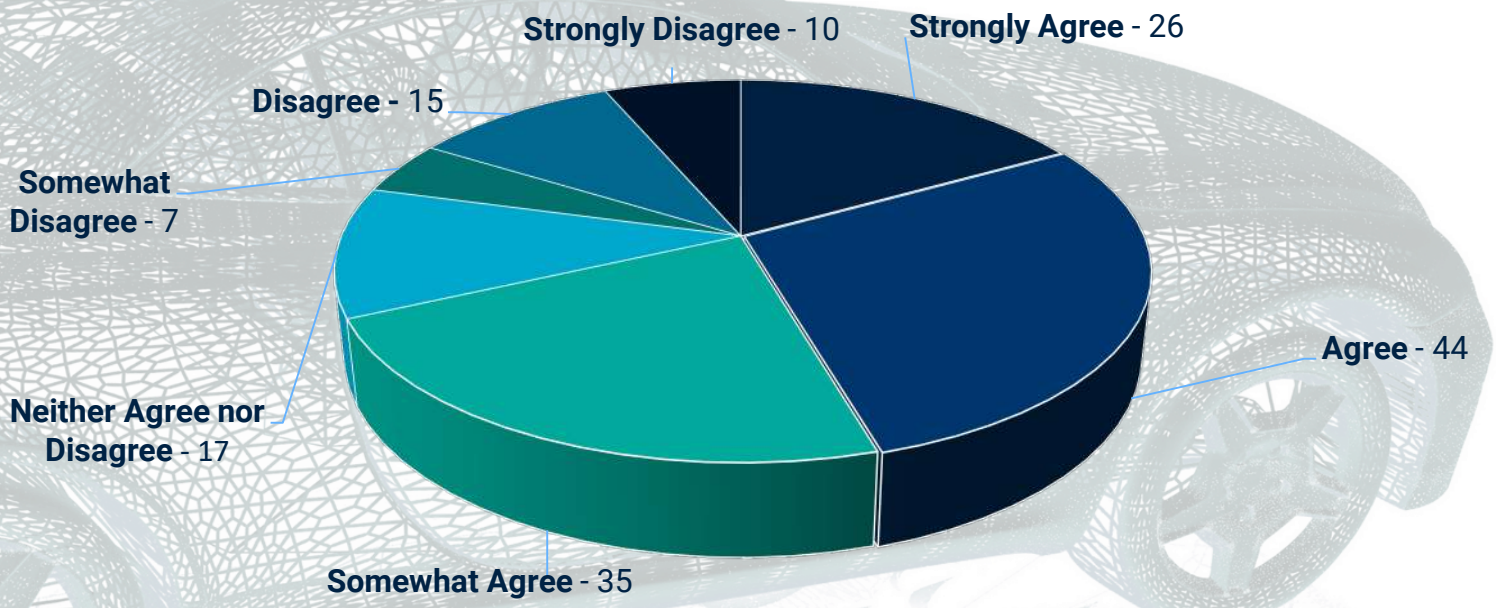
To what extent do you agree with the statement, "*The societal effects of COVID-19 will significantly deter the use of shared mobility vehicles*"?



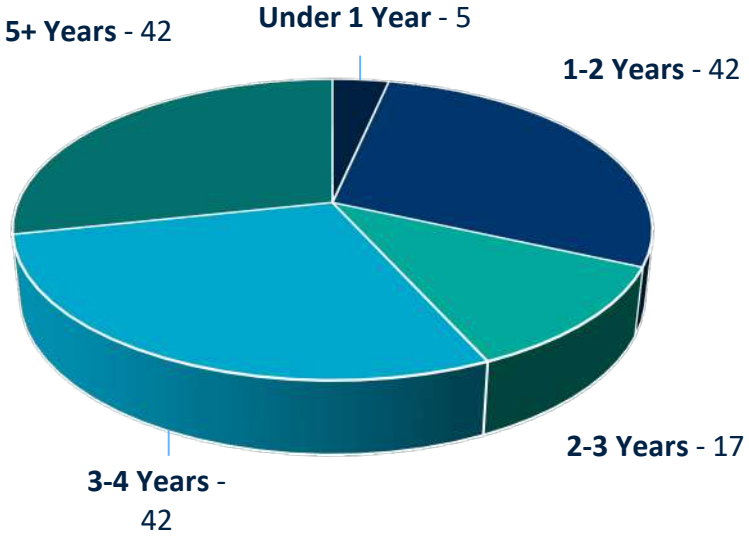
There is no doubt that the biggest hit to the industry this year has been the COVID-19 pandemic. We've seen sales grind to a halt and manufacturing plants shut down entirely. Yet, there is little clarity on how this will alter the trajectory of EV adoption in the short-medium term. 37% of respondents saw the lasting effects of the pandemic as likely to significantly hamper adoption over the next 2 years, while 38% did not believe this to be the case. Our survey did reveal that initial vehicle cost is a significant setback to adoption, and it may be that buyers resort to cheaper ICE vehicles during times of financial uncertainty.

The short-term outlook for the e-mobility industry doesn't look much better. ¾ respondents saw the societal effects of COVID-19 as a significant deterrent to the use of shared mobility vehicles. A mere 14% disagreed. The increasing number of ethical consumers have been opting for shared mobility over personal vehicle ownership on environmental grounds. If this is no longer feasible, personal EV ownership will become a tempting alternative for them.

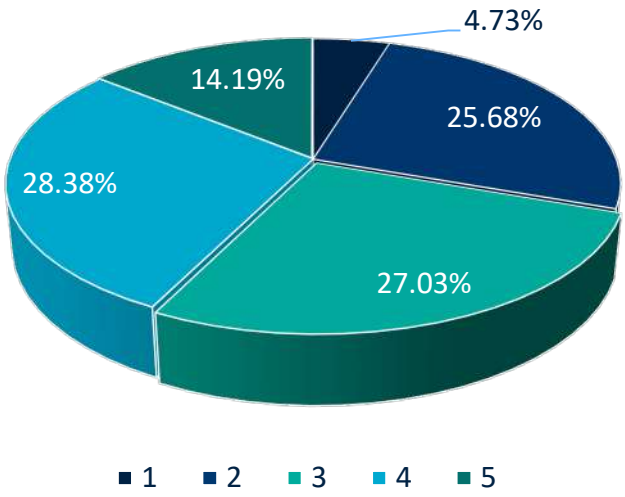
To what extent do you agree with the statement, "*Hybrid vehicles provide the best solution for overcoming short term range anxiety issues*"?



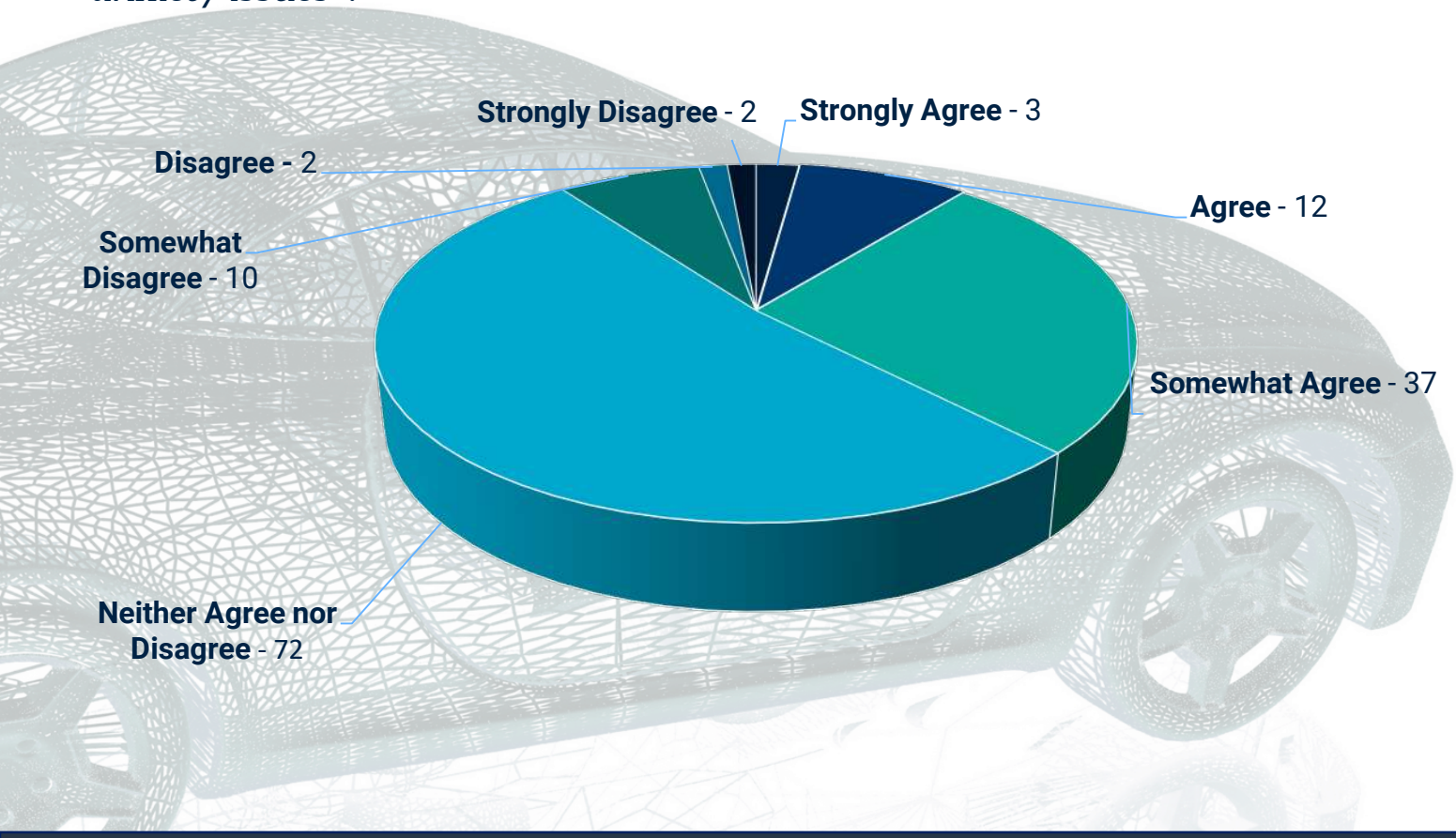
When will we see next generation power electronics, such as SiC & GaN, take prevalence over silicon?



From 1 (highest) to 5 (lowest), how likely do you think batteries will see a shift from LI-ion in the near future?

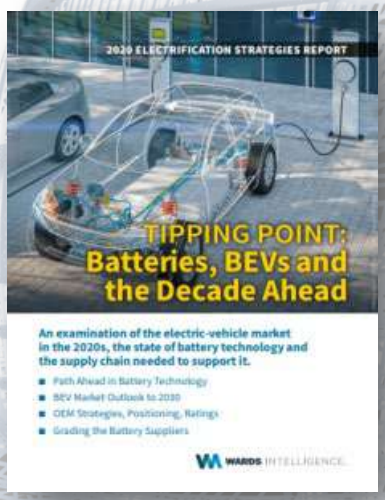


To what extent do you agree with the statement, *"Cell isolation technologies provide the best solution for overcoming short term range anxiety issues"*?

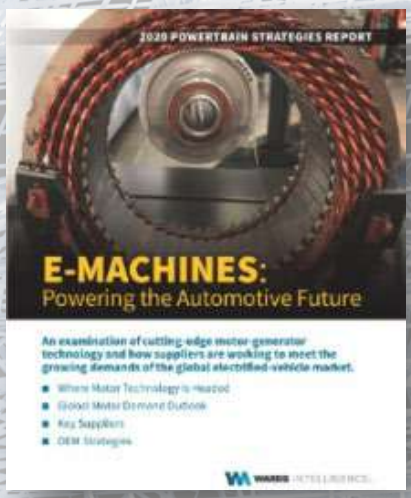


WARDS INTELLIGENCE™

Wards Intelligence Reports combine in-depth insight, quantitative forecasts, market voices, key supplier profiles, OEM assessments and expert Wards analysis on disruptive, game-changing automotive technologies and trends. With our industry-specific reports, you can dive deeper into the following focus areas: autonomy, commercial vehicles, connectivity, electrification, markets, mobility and propulsion.



- How are key global automakers approaching the BEV market?
- Which automakers are planning to launch the most new BEVs over the next 10 years?
- Which automakers will dominate sales through 2030?
- Which battery suppliers are best positioned today, and which others are worth watching?
- What's the state of BEV battery technology and what's coming next?
- What policies are driving the BEV market?



- How are key automotive suppliers adapting to an electrified future?
- Which e-machine suppliers are in the best position to benefit from EV growth?
- Which new players in the e-machine space are worth watching?
- How are e-machine technology and ancillary systems evolving and what's coming next?
- How are OEM and supplier relationships evolving in the age of electrified vehicles?
- How is the e-machine business growing in relation to electrified-vehicle production?

- What compels cities to work with mobility providers?
- How do cities approach partnering with mobility providers?
- What's required for mobility providers to work with cities?
- What policy and technology solutions are unique to city-centered mobility projects?
- Which city departments are involved in mobility projects?

WardsIntelligence.com/Reports

2020 POWERTRAIN STRATEGIES REPORT

SAMPLE

Full Report: WardsIntelligence.com/Reports

E-MACHINES:
Powering the Automotive Future

An examination of cutting-edge motor-generator technology and how suppliers are working to meet the growing demands of the global electric-vehicle market.

- Where Motor Technology Is Headed
- Global Motor Demand Outlook
- Key Suppliers
- OEM Strategies

WARDS INTELLIGENCE™

ABOUT THIS REPORT

Development, refinement and production of internal-combustion engines defined the 20th century, a role electric motors increasingly will claim as we look ahead to the middle of the 21st century and beyond. With nearly 500 BEV nameplates representing nearly 8 million units entering the global market by 2025, and another 20 million hybrids along with them, the demand for motors – "e-machines," considering their ability to function as both motor and generator – is expected to quintuple in the next few years to keep pace.

"E-Machines: Powering The Automotive Future" provides a detailed examination of motor-generator technology along with a thorough review and grading of nearly two dozen motor suppliers developing and producing e-machines to meet the growing electrification demands of the automotive market. This report looks at the global and regional markets for e-machines and includes valuable data on projected motor installation rates by OEMs, as well as results of an exclusive industry survey on the technology.

Among the findings:

- Advancements in batteries and charging infrastructure are essential to the success of automotive electrification, but development of e-machines and an industry to support global electric-vehicle demand are garnering a fair share of attention from automakers and suppliers striving to meet the challenges of this new brand of transportation.
- E-machine production must ramp up significantly not just because of the growth of the EV market, but also as a result of the way electric vehicles are designed, often incorporating more than one motor, whether to provide extra propulsion or all-wheel-drive capability, or both.
- When we look at projections for various EV types, the number of motors averages 1.2 per vehicle; however, that estimate is likely conservative given factors such as the higher market demand for AWD among EV buyers compared with purchasers of ICE vehicles.
- Automakers and suppliers are redefining their roles when it comes to propulsion system development, with suppliers often taking the lead due to their deeper knowledge of electrification. As electric vehicles proliferate, watch for OEMs to take an increasingly firmer hand as they scale up production and look for ways to differentiate their powertrains.

Included in this report are verbatim Q&As with key executives from a cross-section of the industry and results of an exclusive Wards Intelligence survey.

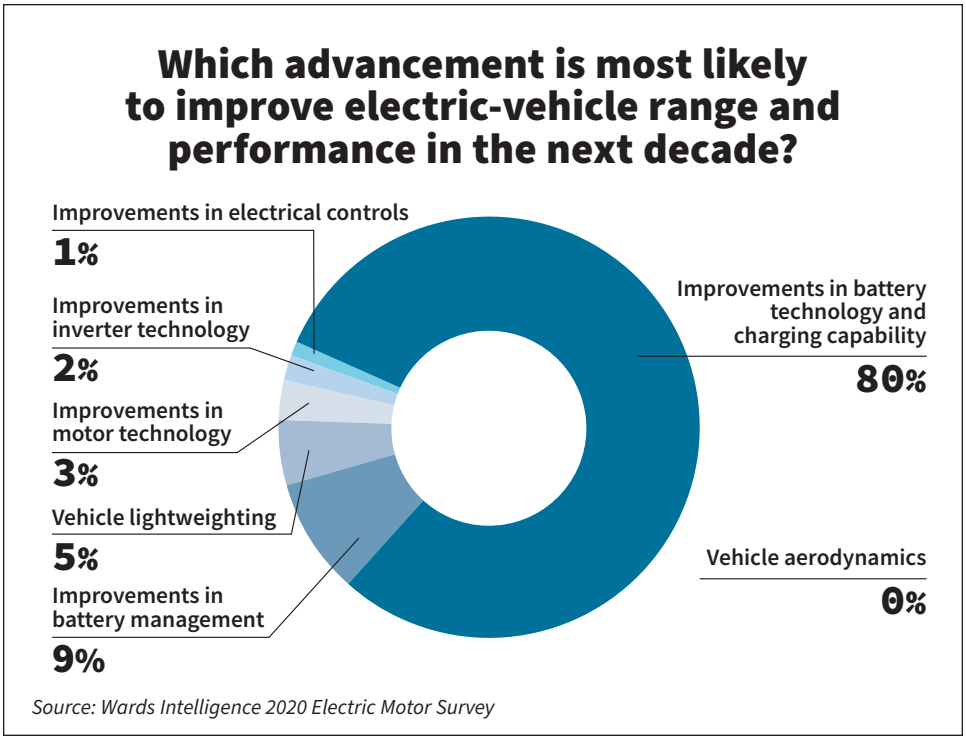
I. OVERVIEW

Batteries and charging infrastructure are central for automakers striving for an electrified future, but the motors and ancillary systems that make up battery-electric and hybrid powertrains also play important roles. In the same way automakers continue to prod ever more efficiency from internal-combustion engines, OEMs and their motor suppliers are recruiting and honing their talents to improve the efficiency, noise, vibration and harshness and performance of motors that will drive the coming wave of electric vehicles.

That focus on electric motors – often dubbed "e-machines" because they function both as traction-drive motors and electrical generators, depending on the flow of power through their rotors and stators – comes none too soon. The global automotive industry is in the early stages of a major transition to all manner of electric vehicles, from simple 48V mild hybrids to battery-electric performance cars and trucks powered by high-voltage all-wheel-drive systems. The coming decade will see some 7,000 electric-vehicle nameplates enter the market, including nearly 500 in the U.S.

To support all those EVs – including hybrids, battery-electrics and fuel-cell vehicles – growing from 6.5 million today to an estimated 31.6 million in 2027, our Wards Intelligence/LMC Automotive forecast suggests the industry will demand nearly 36 million e-machines by 2027, with a market value estimated at better than $36 billion.

Even though motor demand is growing exponentially, the Wards Intelligence survey conducted for this report that supports our theory OEMs and their suppliers to date have been putting emphasis on the power supply before the power unit in electrified-vehicle development. OEMs and suppliers agree that battery and charging technology rank ahead of motor improvements as the most likely paths to increasing electric-vehicle range and performance in the coming decade. Our survey shows batteries and charging are top of mind for 81% of suppliers and more than three-quarters of automakers, while improving electric motors is a mere blip on the radar, ranking after improving battery management and vehicle lightweighting for OEM respondents.



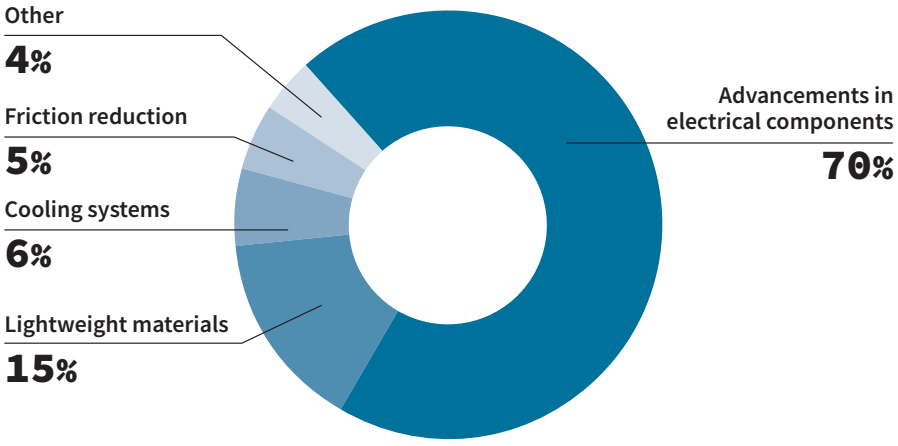
But while electrified-powertrain improvements may not appear front and center in the overall development of EVs, behind the scenes automakers and their powertrain suppliers are highly focused on increasing efficiency of motors and high-speed motor-control switching units as part of an overall path toward increased range and performance of EVs. As noted by several engineers and experts interviewed for this report, even a small percentage improvement in motor efficiency cascades throughout the vehicle, allowing for a smaller, lighter battery or improved range with the same size battery. Performance gains through lighter-weight high-speed motors translate directly into reductions in the mass of every vehicle component, from suspension to braking to steering. Saving weight in the propulsion system and chassis also allows automakers to add more of the consumer-friendly comfort

and convenience features that mass-market buyers expect, but often must be stripped to save weight in more rudimentary electric vehicles primarily designed to comply with government regulations.

Another indicator is the creation of specialized e-machine or “e-mobility” units within automakers as well as within traditional automotive powertrain suppliers, signaling a distinct shift in R&D investment to motors. In addition, non-automotive-propulsion players with expertise in everything from small accessory motors (for parts such as braking actuators) to heavy-duty industrial or commercial applications (such as locomotives), are expanding their portfolios into the light-duty automotive traction-motor sector.

Within those e-mobility departments, leaders already are identifying the elements requiring the most focus and investment when it comes to improving e-machines. In our industry survey, respondents were consistent in their overwhelming opinion that advancements in motor components such as wire windings and magnets hold the highest promise for improving vehicle range and performance and as such were expected to receive the lion’s share of R&D funding in coming years.

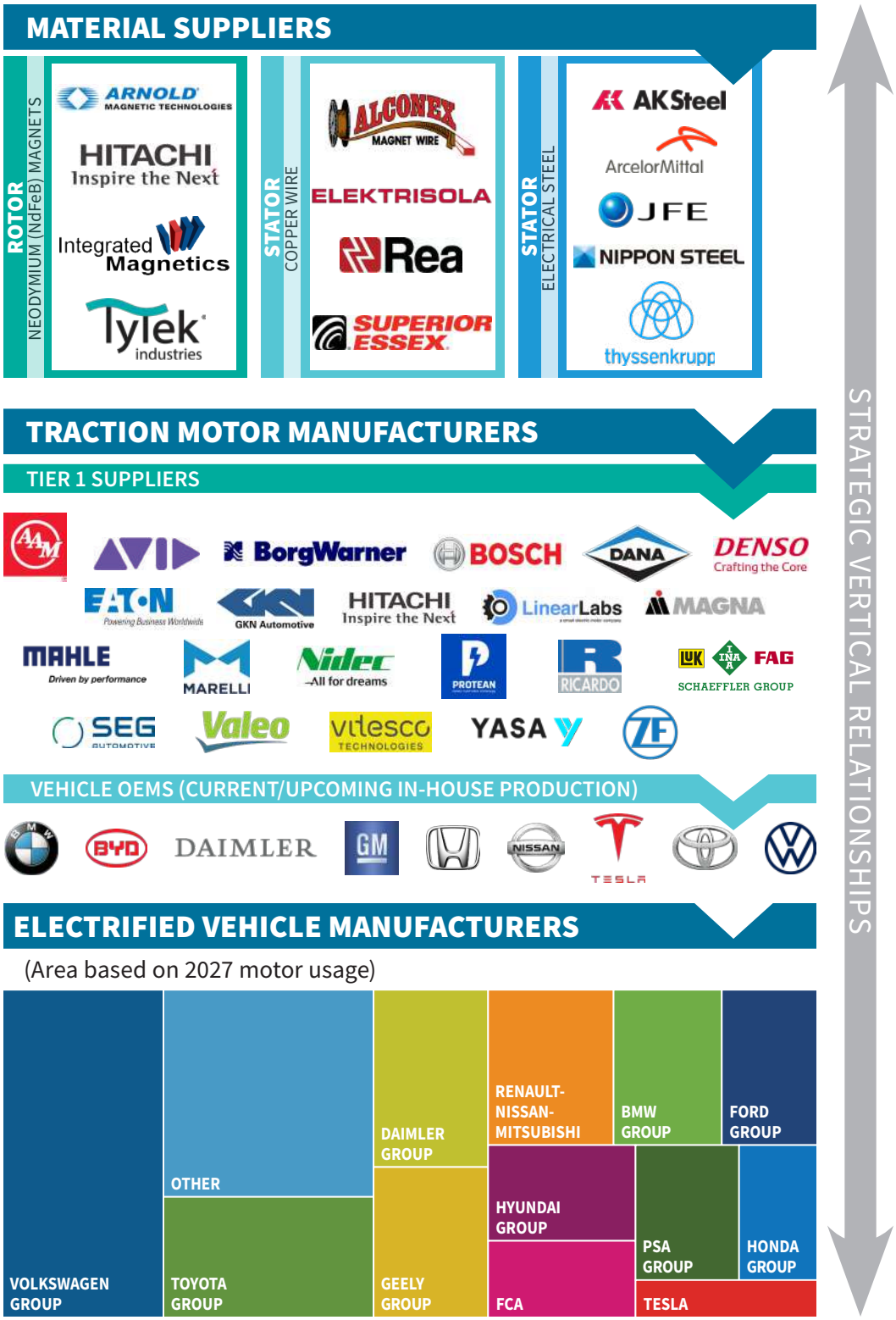
Which of the following advancements in motor technology will receive the highest level of R&D funding in the coming decade?



Source: Wards Intelligence 2020 Electric Motor Survey

All this activity means business will boom for key players in the e-machine supply chain as demand for motors soars. The primary material in the rotors, neodymium (NdFeB) magnets, is supplied by companies such as Arnold Magnetic Technologies, Integrated Magnetics and Tytek Industries. Hitachi

E-MACHINES SUPPLY CHAIN



supplies its own magnetic materials for its motors. For the stator, electrical steel is supplied by ArcelorMittal and Thyssenkrupp, among others. Copper wire suppliers include Elektrisola, Rea and Superior Essex.

Tier 1 suppliers are detailed in this value chain, but some automakers seek to keep development and manufacturing in-house. Based on volume, Volkswagen, Toyota and Daimler rank highest for e-machine demand in 2027, and all three will have proprietary units that supply their e-machines.

TECHNOLOGY'S ROLE

Permanent-magnet motors are the most common type used in automotive applications, although Tesla has employed induction motors. Permanent-magnet units rely on rare-earth-mineral magnets arrayed on a rotor and attracted by magnetic forces created when electricity flows through wire windings in the surrounding stator. They are preferred by automakers for their smooth and quiet operation, instant power from zero rpm and high efficiency in low- and mid-speed use. Induction motors eschew magnets and instead use additional windings on the rotor in which magnetic fields are electrically "induced" to create motion. While the lack of rare-earth metals is a plus, induction motors suffer from poor efficiency at lower speeds where most driving occurs, making them less desirable for all but high-performance EVs. Engineers also are studying alternatives that reduce or eliminate the reliance on rare-earth magnets without increasing the mass of the motor and while maintaining quiet, seamless operation.

Even though motors are already highly efficient, operating at more than 90% efficiency (compared with internal-combustion at just 40% for some of the most thermal-efficient engines), improving motor efficiency is taking on renewed emphasis. Automakers are looking for every advantage as they seek to increase the range of their electric vehicles, especially in BEVs that are solely reliant on stored energy and vehicle efficiency to achieve desired miles per charge. Even small efficiency gains at the motor level can translate into valuable increases in range or vehicle performance.

Use of specialized winding techniques to pack more wiring into a smaller space, improvements in cooling and increasing motor speeds are all earning the attention of engineers. As motor speeds increase – 20,000-30,000 rpm is not unusual – engineers must grapple with managing heat, friction and NVH as well as using proper gearing and specialized transmissions to obtain the highest efficiency from advanced e-machines.

Achieving the right balance between the speed at which a motor is most efficient and still meets vehicle performance demands is key. Optimizing

the motor and elements external to the actual motor, such as the type and efficiency of chips employed in controllers, is becoming crucial to overall efficiency.

Specific automotive applications also require motors of different types and capabilities. A relatively simple stop-start system may employ a single, lightweight 48V belt-driven starter-generator such as those employed on FCA's Ram pickups and Jeep Wranglers; the more robust stop-start setup on Mercedes-Benz 3.0L I-6 powertrains incorporates a 48V direct-drive motor sandwiched between the engine and transmission that also works in tandem with the engine to provide 21 hp and 184 lb.-ft. (249 Nm) of blended propulsion.

Powerful, high-voltage traction motors in BEVs such as the Chevrolet Bolt produce 150 kW (201 hp) of output from a single, permanent-magnet motor sufficient to power the vehicle from a standstill to 60 mph (97 km/h) in 6.9 seconds with 259 miles (417 km) of range. BEV leader Tesla's dual-motor system incorporates both permanent-magnet and induction motors in its various AWD models, combining strengths and offsetting weaknesses of the motor types. Drawing on permanent-magnet and induction power enables the Model S sedan to achieve a 2.4-second 0-60-mph time in Ludicrous mode while maintaining nearly 350 miles (563 km) of maximum range. Electric all-wheel drive represents a steadily growing market for motors, incorporated as a self-contained e-axle addition in an ICE vehicle or in a BEV such as the Jaguar I-Pace.

Automakers and suppliers agree the transition to designing, engineering and manufacturing electric motors with a single moving rotor will require a significant shift in operations and skill sets compared with developing far more complex internal-combustion engines with hundreds of moving parts. BEVs require engineering efficiency in the motor working in upstream combination with the electrical system and power supply, while ICEs demand attention to engine efficiency impacted by downstream management of emissions, note respondents to our survey. Many suggest the electric motor is in the infancy of its development compared with more than a century of ICE refinement.

"We have 100 years of practice with ICE, both developing and producing," says one survey respondent. "We have perhaps 20% as much experience with electric motors, batteries and controllers."

Another respondent notes engineering a motor may be "less complicated on a system level, but still requires considerable improvement on the current technology level, particularly in regard to cost effectiveness and enhancing efficiency, driving range, performance and charging speeds."

OEM STRATEGIES

As automakers face myriad demands for R&D investment in autonomous vehicles, battery technology and internal-combustion-engine programs, they often are taking a mixed approach to e-machine engineering and production. While a small number of OEMs prefer to keep all motor work and production in-house, many find it wiser to rely on suppliers who already possess deep knowledge and capabilities when it comes to motors. A common strategy, at least for now, is a blended approach in which the automaker provides detailed design parameters for a supplier or suppliers to execute from prototype to production. That work can involve engineering everything from the motor to a fully optimized system including the motor, gearset or transmission, controller, inverter/converter, wiring and connectors and even the battery and on-board charging system.

German automakers, including Volkswagen, which is in the process of completely remaking its product focus toward electrification, tend toward developing and producing motors in-house, while Asian OEMs lean heavily on suppliers. Global hybrid leader Toyota, for instance, depends nearly entirely on Japanese suppliers Aisin and Denso for its motors while Honda gets its motor supply from Hitachi. U.S. automakers are a mixed bag: GM counts on South Korea's LG for its motors; Tesla builds its own.

Whether built in-house or pulled off a supplier's shelf, differentiating motors in the same manner as ICEs may be the toughest hurdle. In a nod to the enduring consumer awareness of certain ICEs such as the BMW I-6, FCA's Hemi or the small-block Chevy V-8, one survey writer sees black clouds on the horizon for marketers: "In the past, manufacturers differentiated themselves with ICE technology. Do customers care whose motor/inverter has higher technology?"

GRADING THE SUPPLIERS

Of the 23 motor suppliers we've included and evaluated in the Supplier chapter of this report, more than half rated a top grade for their leadership in development and production.

European companies make up a preponderance of suppliers topping our list, including German automotive powerhouses Bosch, Mahle, Schaeffler, Continental spin-off Vitesco and ZF, with U.K.-based GKN also strong in the electrified-propulsion business. All top-ranked companies offer a breadth of product offerings, global market reach and deep roots with OEMs. North American suppliers, including U.S.-based American Axle & Manufacturing, BorgWarner, Dana and Canadian supplier Magna are on equally strong footing with electric motors already in the market and additional products in the pipeline.

WARDS INTELLIGENCE STRATEGIC REPORT CARD — SUPPLIERS

E-MACHINE DEVELOPMENT AND MARKET PROSPECTS

SUPPLIER	COMPETITIVE POSITION
GRADE A: STRONG TECHNICAL CAPABILITY, WIDE PRODUCT PORTFOLIO, SIGNIFICANT MARKET PENETRATION	
American Axle & Manufacturing	Legacy supplier already well-established in electrified business
BorgWarner	Powerhouse propulsion system supplier with aggressive EV plan
Bosch	Solid plans to grow its already robust global EV business
Dana	Wide portfolio of EV products developed with acquisition partners
Denso	Denso, Aisin relationship powers Toyota's global hybrid leadership
GKN	Global OEM customer base, wide range of EV products, more on the way
Hitachi	Honda motor supplier also has deep roots in heavy industry applications
Magna	Multi-faceted motor program strengthens longtime supplier's position
Mahle	Full catalog of electrification systems and motors, from scooters to BEVs
Schaeffler	Extensive expertise in electrification, major products in market
Vitesco (Continental)	High-output 48V motor and e-axles put Conti spinoff in strong position
ZF	Electrification efforts supported by BEV transmission expertise
GRADE B: HIGHLY CAPABLE BUT LIMITED PRODUCT AND/OR MARKET SCOPE	
Eaton	Making progress, but advancements in BEV powertrain still in the works
Mitsubishi Electric	ISG supplier to Mercedes needs to grow its electrified portfolio
Nidec	Big advances in the works, but small-motor supplier still growing
Ricardo	Formula E transmission supplier has bright future in high-speed motors
Valeo	Collaboration with Dana should push French supplier rapidly to top
GRADE C: HIGHLY SPECIALIZED OR STILL DEVELOPING TECHNOLOGY AND/OR MARKET REACH	
Avid	Newcomer likely to make future moves with specialized motor
Linear Labs	Innovative technology but lacks marketing, OEM ties
Marelli	Merger should help bring longtime electrical supplier out of shadows
Protean	Singular focus on wheel motors should pay off longer term
SEG	Focus on 48V technology limits reach, but market objective solid
Yasa	Single-product focus for now, but OEM customer base rapidly expanding

Asian leaders are primarily Japanese suppliers to Toyota and Honda (Aisin-Denso and Hitachi, respectively), although B-grade-rated Mitsubishi Electric is the source of motors for German automaker Mercedes-Benz.

Worth keeping tabs on are the nearly half-dozen U.K.-based suppliers, including the aforementioned GKN but also transmission specialist Ricardo now branching into high-speed electric motors and several smaller firms with interesting motor products and high aspirations, including Avid, Protean and Yasa. Just over the horizon is South Korea's LG. More widely known as a battery maker, LG is not ranked among our 23 suppliers, but as the sole supplier to GM, its motors business is growing quickly and will likely join our list going forward.

CONCLUSION

Automakers and automotive suppliers are steeped in the design, engineering and manufacture of internal-combustion engines, and remain committed to further evolution of those powerplants. But as the industry shifts to electric vehicles between now and 2050, R&D investment inevitably will transition to the improvement of e-machines as part of a larger effort to increase the efficiency of all types of EVs, from 48V mild hybrids to high-performance BEVs. For now, suppliers are leading e-machine development, but automakers already are seeing the need to take on more ownership of their advanced electric propulsion systems. Some OEMs currently manage their motors from design to production while others rely almost entirely on suppliers for motor expertise. In between are those OEMs with strong partnerships with suppliers that are likely to remain in place well into the coming decades.

Although motor improvements at present hold less promise for immediate gains in BEV range compared with advances in batteries and charging, it is evident OEMs and suppliers see potential in increasing e-machine function, efficiency and performance over the long haul. New motor designs, high-speed motors, e-transmissions, specialized thermal management, friction reduction and advanced ancillary controls all are part of the efforts to engineer superior e-machines to support the coming wave of electric vehicles. And as battery and charging systems reach development maturity, even more attention will shift to e-machines as engineers seek out higher efficiency and marketers push for ways to brand and distinguish the propulsion systems powering their future vehicles.

GET IN TOUCH

CONTENT & SPEAKING INQUIRIES

Caroline Hicks
T: +44(0) 203 377 3841
E: caroline.hicks@informa.com

EXHIBITION & SPONSORSHIP INQUIRIES

Sanjay Singh
T: +44(0) 207 551 9828
E: sanjay.singh@informa.com

MARKETING, MEDIA PARTNER & PRESS INQUIRIES

Freya Smale
T: +44(0) 207 017 5185
E: freya.smale@informa.com