STRATEGY ENGINEERS

Study

Electrified growth with electric drives

How electric systems and components create business opportunities for suppliers

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Management summary

Electrification is shaking up the automotive industry, especially at established automotive OEMs who have initially been tentative to investigate and develop electrified powertrains. Driven by strict emissions legislation, strong public awareness, and growing interest from customers, OEMs have started to embrace the idea of electric vehicles and develop increasingly affordable and useful cars.

With the first generation of electric cars coming to the market, competitive dynamics are increasing. We forecast rapidly growing electrification until 2030 in both Europe (24.1 mn units / 100% electrification) and China (36.4 mn units / ~80% electrification). In parallel to volumes ramping up, automotive supply chains will dramatically change. Long-established value chains are disrupted, creating business opportunities for suppliers who set the stage and plug in for electrified growth.

In this study, we look at an electric drive axle as reference case for analysis. An electric axle (also called electric drive unit) comprises several complex electrical and mechanical systems. It typically consists of an electric motor, power electronics, a thermal system, a transmission and a housing. Our analysis suggests that highest margin potential is in power electronics, while system integration is only poorly rewarded. From a material cost perspective, power electronics and the electric motor dominate – accounting for about 27% of total material cost each.

How can suppliers enter the market for electric axles and earn money? We describe four electrification plays for suppliers, ranging from component to system level. Among these, only a positioning as either component or system supplier will provide sustained profits. Component suppliers with high own value-add can defend their margins against competition and OEM purchasing tactics. System suppliers need to generate non-replicable value through electric, mechanical and thermal integration and need to become good at defending this value towards OEM customers and Tier 2 suppliers.

In positioning their offerings, suppliers need to be aware of actual demand and business opportunities. In the short term, only Global Niche OEMs (e.g. Jaguar Land Rover or Ferrari), Local OEMs (Follower), and Service newcomers (e.g. uber or DiDi Chuxing) are likely to be interested in system supplies for e-axles. The reason is, that most other OEMs are investing to build internal competences. With increasing maturity and the next vehicle generations, this insourcing trend is expected to reverse. Like other commodities, e-axles will be sourced on higher integration levels as soon as a state-of-the-art in technology has been created and OEMs have obtained market transparency. This opens a window of opportunity for system suppliers to develop their technology and supply chain for next product generations.

Suppliers should use this time to prepare beyond developing competitive technology. To enable a profitable and sustainable electric-axle business on system level, they need to transform and rethink existing organisational boundaries. Going forward, they need to master development & validation as well as manufacturing technology. Even more so, they need to be knowledgeable on system and complete vehicle level.

In summary, suppliers can benefit from electrification if they carefully select their target customers, focus on either component or system level and align their capabilities accordingly.

Introduction

As technology matures, automotive original equipment manufacturers (OEMs) increasingly outsource development and divest their supply chain. This pattern has been observed throughout the past 30 years of vehicle manufacturing. Suppliers have seized this opportunity to broaden their product and service portfolios – capturing increasingly large shares of automotive value creation.

OEMs have started to prepare for the electrified age – suppliers need to position accurately to benefit

For the last five years, the key innovation topic for automotive powertrains has been electrification. Largely driven by a challenging combination of tightening emissions regulation and new competitors with recognisable market success, incumbent OEMs must come to terms with electrification. As production volumes and actual customer demand for electric vehicles (EVs) finally ramp up, OEMs are no further hesitant to prepare for the uncertain time after the internal combustion engine (ICE). Directly linked to this process, OEMs are reconsidering their role in the automotive supply chain. This can be observed in the ongoing discussions of bringing more electrification competence in-house, e.g. with development and manufacturing of battery packs and electric motors.

In parallel, new supplier markets related to electrification are emerging while others – linked to ICEs – slowly but continuously decline. Overall, the disruption caused by electrification creates business opportunities for suppliers as powertrain complexity increases. As electrified powertrains require different capabilities and involve more and more software, long-established commodity structures and supplier relationships open in need of access to new intellectual property. In a volume-wise stagnant vehicle market, suppliers must set the stage now to benefit from electrified growth.

With this study, we address four questions which need to be answered in preparation:

- What electric drive system technology to develop, and when?
- What to build, systems or components?
- How to refund investments into early concept and engineering work?
- How and when to change the internal organization for the new business?

Automotive powertrain technology and market development

Tesla has been the key disruptor for automotive electrification. Not considered a serious competitor in the beginning, incumbent OEMs are now struggling to meet the real-world efficiency of the Silicon Valley's leading powertrains as they launch their first EVs. After a first phase large in hype but small in actual offers, the market for EVs is now actually growing (see Figure 1). Until 2030, OEMs will be offering their second and third generations of vehicles. This means, that a new state of the art in propulsion technology establishes. Until then, suppliers need to have executed their next strategic steps to build, sustain and defend competitive advantages.

Market forecast: xEV technology adoption

Strategy Engineers has developed an xEV market forecast model to address the first two questions raised in this study. The model builds on bottom-up sales volumes including details on markets and powertrain technology. Setting up the model, we

leveraged internal expert know-how and aggregated development insights from our mother company AVL. Quantifying the described surge of electrification, our model yields continued increase in xEV penetration from 2019 onwards. For the forecast period until 2030, the European market is characterised by stagnating volumes and substitution. This means, that xEVs replace ICEs while the total market size grows only ever so slightly. Our European forecast reads 24.1 mn units in 2030 – all of which will feature an electrified powertrain (see Figure 1). This means new vehicles are ranging from mild and plug-in hybrid electric vehicles (MHEV / PHEV) to battery electric vehicles (BEV) and fuel cell EVs (FCEV).

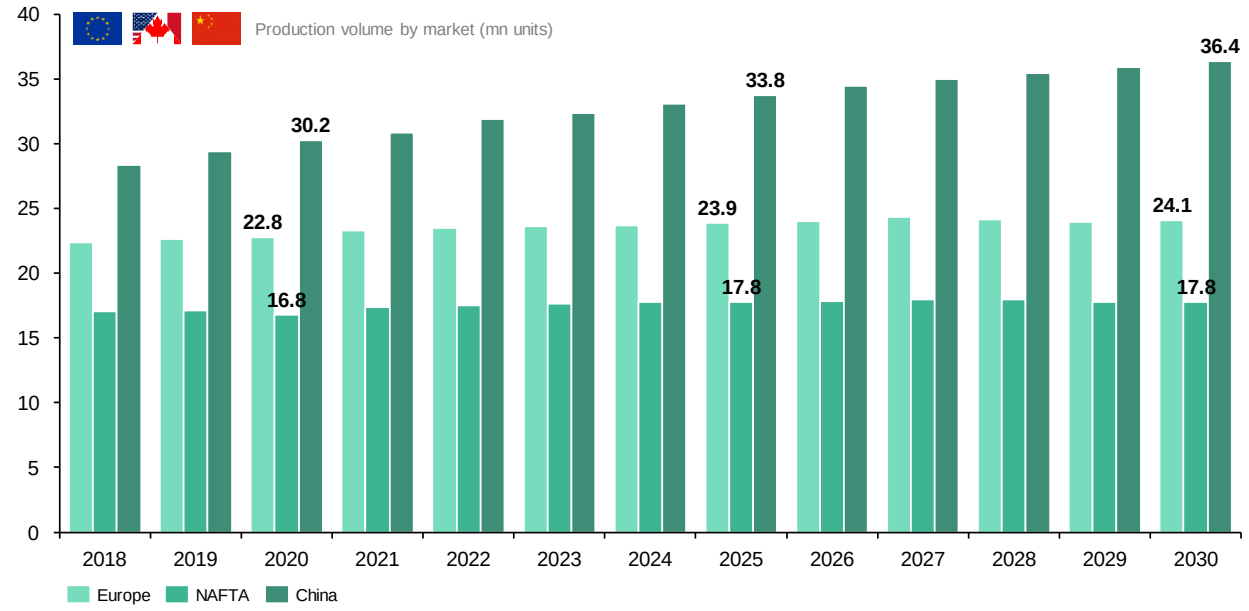

Figure 1: Strategy Engineers xEV market forecast in Europe, China and North America (NAFTA)

Other than in Europe, the overall market in China is forecast to grow continuously until 2030, reaching a size of 36.4 mn units. Electrified powertrains are forecast to outgrow conventional powertrains during the same period, yielding an electrification share of 80% in 2030. As a result, China is and remains the leading xEV market. In contrast, the North American market is forecast to show significantly lower figures, both for sales volumes and in terms of electrification. More detailed information about the powertrain technology splits on the discussed markets is presented in Figure 2.

China will reach 80% xEV share in 2030 and stays the leading market for electrification

In its assessment for the key markets in Europe and China, our forecast is more ambitious than other data presented. This builds on three fundamental insights:

» **Penalties:** The understanding that OEMs will prioritise developing and selling xEVs overpaying penalties for exceeding fleet emission targets.

» **Restrictions:** The assumption that governments and cities will increasingly ban combustion engines from inner city areas and combustion of fossil fuels will be penalised to support achieving the Paris climate goals.

» **Demand:** The believe that customers learn to like electrified vehicles.

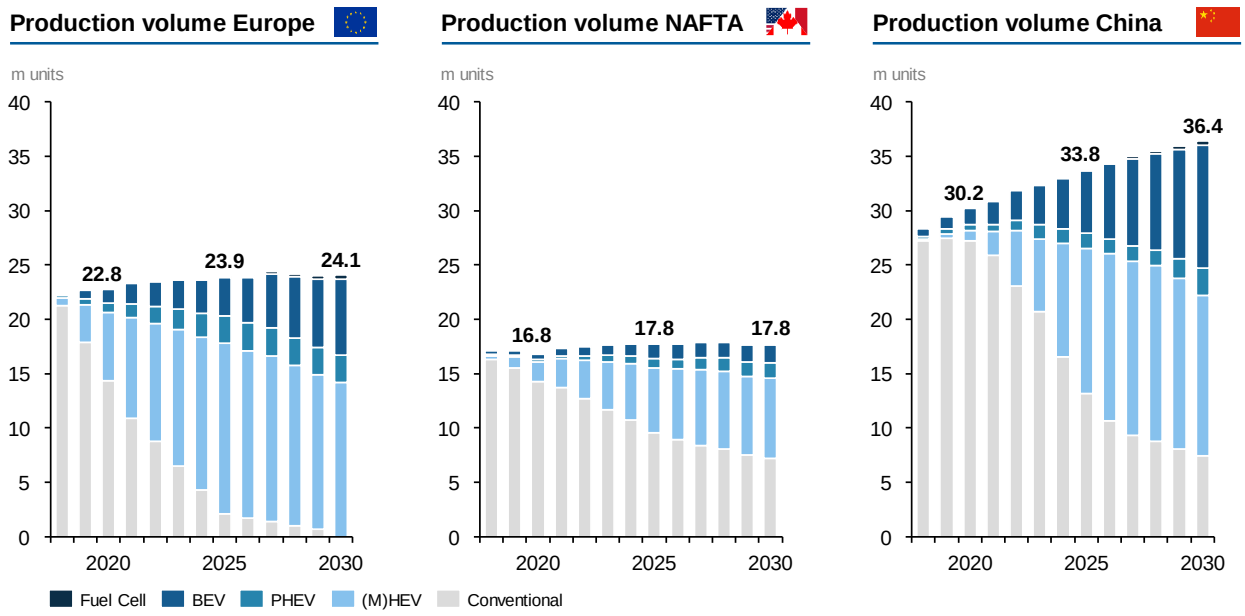

Figure 2: Strategy Engineers xEV powertrain topology penetration forecast in Europe, China and North America

(M)HEVs will dominate powertrain topologies in Europe until 2030

The strongest growth in xEV market penetration in both Europe and China is expected until 2025. By that time, almost all OEMs will have their first or second generation of xEVs on the market. This development meets growing customer demand for electrified powertrains – both for small city and purpose-build cars (most of them BEVs) as well as for larger, more versatile cars (B/C/D segment; (M)HEV / PHEV). In Europe, we forecast (M)HEVs to be the largest segment from 2025 on. BEVs will outnumber PHEVs while FCEVs are expected to play only a minor role in the powertrain split. Despite the shared understanding that fuel cell technology could become the most resource and emission friendly solution, we do not yet see signs for infrastructure development and large-scale vehicle programmes.

Summarising the developments, launches and announcements in recent months, it is apparent that the question is not if electrification will come but rather when and for which application. Hence, suppliers need to be prepared for the changing market and competitive environment.

Market segmentation and target applications

Building on the understanding that the market for electrified powertrains will grow in the years to come and be the dominating technology from 2025 onwards, suppliers need to segment their target market and select focus applications.

Figure 3: Passenger car OEM market segmentation based on make-or-buy for electrified powertrains

For passenger cars, we propose a segmentation into seven OEM segments (see Fig. 3). This segmentation is based on an assessment of OEMs' make-or-buy strategies for electrified powertrains. There are three factors defining these strategies:

From a supplier's perspective, OEM segmentation is made based on make-or-buy strategies

» **Technology strategy:** Targeted share for in-house development competence

» **Scale and platform synergies:** Large vs. small production volumes on standardised vs. vehicle specific platforms

» **Production strategy:** Targeted share for in-house production

Strategy Engineers applies a four-level framework for strategic OEM sourcing to differentiate the corresponding supplier plays. On the highest integration level, OEMs source integrated systems while on the lowest level, it is single components. In between, there are sub-systems and sub-assemblies. The full framework and typical supplier purchasing scopes are presented in Figure 4.

The overall trend distilled from expert interviews is that Global Premium and Volume OEMs are insourcing to build internal know-how, while Global Niche OEMs, Local OEMs (Follower) and Service newcomers are more open towards system supplies. The objective for Global Premium OEMs and Global Volume OEMs to insource is developing resources and capabilities in electrified powertrains. In addition, these companies usually employ large production teams they need employment for. With BEV powertrains generally reducing manufacturing complexity, in-sourcing of production steps is a means to create employment opportunities. As a result, these (largest) market segments focus on component supplies and do hardly allow suppliers to capture system business.

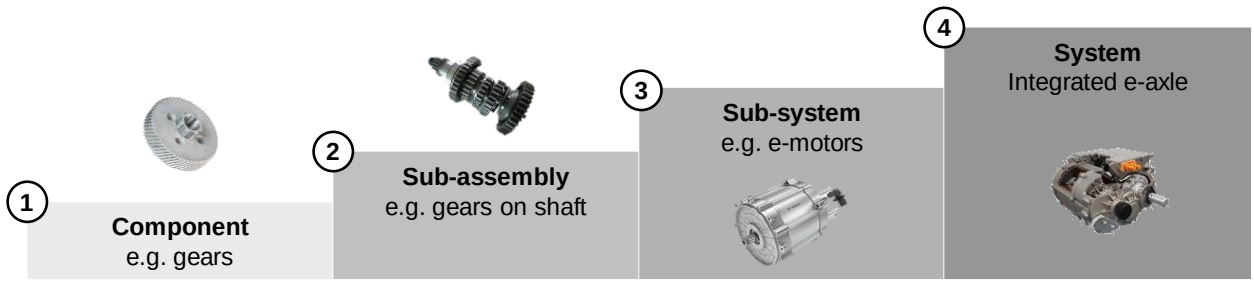

Figure 4: Strategy Engineers framework for OEM demand and supplier plays

A similar logic applies with Local OEMs (Leader). Other than the Global Premium and Volume OEMs, they face lacking engineering resources. As a result, suppliers can capture some business in the development of electrified powertrains up to sub-system level, helping the OEM to reduce time to market. Still, the employment-challenge in production is comparable to the other OEMs.

In contrast, Global Niche OEMs, Local OEMs (Follower) and Service newcomers are interested in strong partners to execute their electrification plans. For these OEMs, experienced Tier-1 suppliers can become valuable development partners competing with engineering service providers. Considering the different company structures represented in these segments (ranging from Government-funded organisations or established OEMs to venture capital backed start-ups and technology companies), it is apparent that there is no one-size-fits-all application.

Product newcomers with innovation based on design are the sixth OEM segment. Lacking heritage organisations and in need for suppliers experienced in the

automotive industry, these OEMs are in many cases looking for partners for co-development. As a result, suppliers can engage on sub-system and sub-assembly levels.

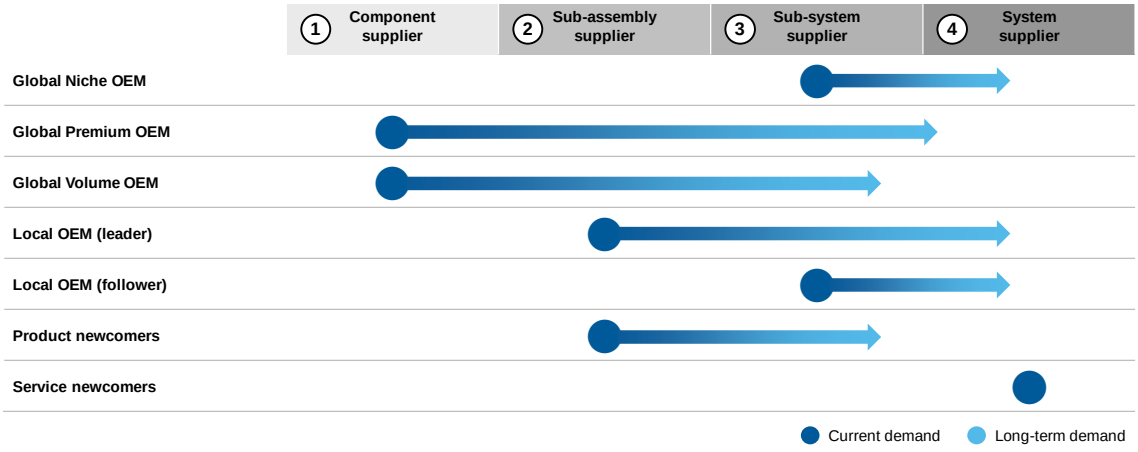

Figure 5: Illustrative OEM purchasing strategies and long-term development trends

The described OEM characteristics (see Figure 5 for a summary) largely refer to the first and second generations of EVs. With increasing internal know-how, the establishment of a state-of-the-art in technology and growing production volumes, our experts expect changes in the described purchasing patterns. Experience with other commodities, e.g. vehicle control or steering systems suggests that with growing maturity, OEMs tend to increasingly source on higher integration levels. This frees internal resources for innovation and allows for cost-optimisation through leveraging synergies and divesting commoditised assets.

Supplier strategies to electrify growth

The four-level framework of supplier integration is not only used to characterise OEM demand, but more importantly to describe and evaluate the strategic positioning of suppliers (see Figure 4). Each of the four plays holds unique potentials for value creation, differentiation and the establishment of competitive advantages. To link the four plays with OEM demand as outlined before, this paper uses an electrified axle (e-axle) as an example. Based on this reference, actual business opportunities and emerging strategies are discussed.

Reference case: Electric axles and supplier integration levels

E-axles are used in various electrified powertrain topologies (for an illustration see Figure 6). In BEVs and FCEVs, they are the sole propulsion unit for the vehicle. For package and driving dynamics reasons, the e-axle is typically used as the rear axle. To create all-wheel drive powertrains, a second e-axle can be added at the front. In hybrid EVs, e-axles are used as secondary power source in combination with an ICE powering the front wheels (“P4” architecture). Structurally, an e-axle comprises of five major sub systems:

- Electric motor
- Power electronics (inverter, converter)
- Transmission
- Cooling system
- Structure and housing

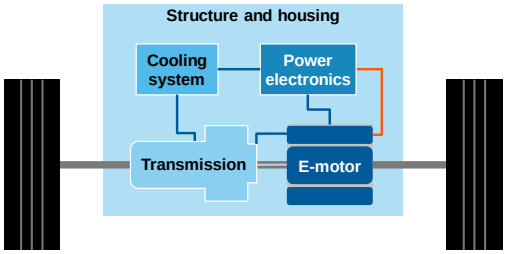

Figure 6: Illustration of an automotive electric axle

Power electronics and electric motor dominate product cost of e-axles

Based on competitive benchmarking and bottom-up cost calculations performed, Strategy Engineers has assessed the typical cost structure of an e-axle designed for mainstream applications. Figure 7 shows the results of this analysis, indicating that electric motor (26.6%) and power electronics (26.9%) hold highest shares of total system value, followed by the required transmission (21.8%). The other sub-systems fall behind these two. In addition, we have analysed the value of integration and assembly. For a generic e-axle, this step accounts for 5.2% of total value.

The four possible supplier plays described in the previous chapter follow the idea of system integration from component to system level. In the first play, the supplier is positioned as component expert in development and manufacturing. For an e-axle, this can be gears, shafts or cables. Building on individual components, a sub-assembly supplier provides basic assembly steps for individual components, e.g. fitting gears to a shaft. A sub-system is created by performing multiple assembly steps on multiple components to create an integrated sub-function. In an e-axle, examples for this supplier level are transmission units including clutch and differential, electric motors, or power electronics. The fourth and highest level in our model of supplier integration is the system play. In this, a supplier provides a fully integrated e-axle including development, testing and manufacturing.

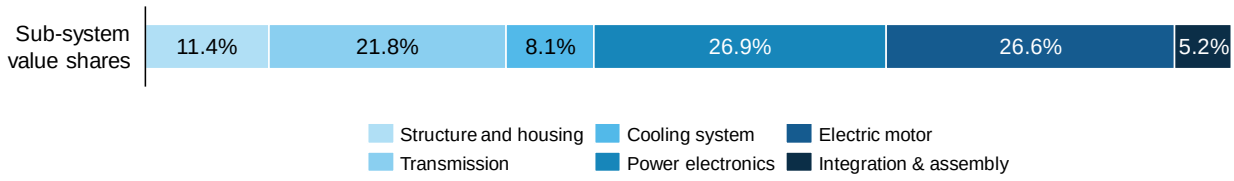

Figure 7: Value structure for a generic mainstream e-axle (75-150 kW, 300-450 V, 250,000 units p.a.)

Business opportunities: E-axle system integration and unique selling propositions

How can the four plays support suppliers in strategically making use of system integration to find the right level of value creation and develop unique selling propositions? We consider three viable starting points for system integration as depicted in Figure 8: Transmission, e-motor and inverter. As they are defined by these three sub-systems, both thermal system and structure do not qualify as starting points for system integration. Integration towards a complete e-axle is done in two steps.

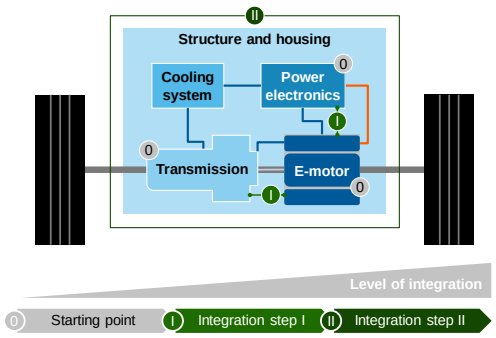

Figure 8: Starting points for integration from sub-system to system level of an e-axle

At the first step of integration, suppliers with know-how in electric motors or inverters could take their key components as starting points to develop an integrated e-motor and inverter. This offers optimisation potential regarding the interplay of e-motor and inverter. Since it has a major impact on system efficiency, this is an opportunity for supplier value creation. The third starting point is hardware-driven: A transmission supplier could integrate an e-motor and the required transmission unit to optimise on package, NVH and assembly. All three are entry points for e-axle integration. However, sub-systems created in this first step might face a "stuck-in-the-middle" position as integration is not complete and differentiation limited.

To unlock full value creation potential and benefit from superior margins in return, suppliers need to investigate the second integration step towards complete e-axles. This opens full optimisation potential as the key challenges regarding mechanical, electrical and thermal integration can be addressed on system level. In turn, suppliers can find innovative solutions across all sub-systems as a source of differentiation and competitive advantage.

		Main e-axle challenges							
		Package and **installation** of e-axle into vehicle	**NVH** of gear set and electric components	**Integration** of **e-motor** into axle	Combination of **axle** and **power electronics**	**Cooling system** electrical components	**Lubrication** of gears and bearings	Component and system **optimisation**	**Testing** and calibration
Value-creation potential	**Mechanical** integration	●	●	●	◑	◔	◕	●	◑
	Electrical integration	◑	◕	◔	◕	●	○	●	◕
	Thermal integration	◑	◔	◑	●	●	◑	●	◕
	Cost	◕	◕	◕	◕	◑	◑	●	◔

Table 1: Engineering challenges for -axles

In total, our analysis identifies eight main engineering challenges for e-axles (see Table 1). Each of the challenges reflects value-creation potentials along four dimensions: (1) mechanical integration, (2) electrical integration, (3) thermal integration, and (4) cost. For example, value-creation potentials originating from superior mechanical integration can be leveraged with package and installation of the e-axle into the vehicle, NVH of the gear set and electric components, or the integration of e-

motor and axle. In contrast, know-how in thermal integration is best used to create a superior offering regarding combinations of axle and power electronics, and the cooling system for electrical components.

Strategic transformation: Enabling supplier profits in electrified powertrains

So how can suppliers make use of these insights, plug in for growth and super charge profitability with electric powertrains? A strategic positioning for a supplier going for e-axle business builds on combining clear, company-specific value propositions with market insight regarding competition and demand. Leveraging insight into their own competitiveness, the target system value and margin structure as well as the key engineering challenges, suppliers can tailor their winning strategy and define the required transformation to execute and deliver.

Strategic market positioning for e-axle suppliers

In positioning their offerings, suppliers need to make informed decisions in which play to engage to secure both value creation and margin potential. Corporate data from representative suppliers analysed by Strategy Engineers suggests that components make more money than systems – despite the usual exceptions. In the EU, China and North America, component suppliers achieve higher profitability than subsystem suppliers as additional assembly services are less profitable than manufacturing tasks performed earlier in the value chain. In addition, specialised companies covering fewer steps of the value chain achieve higher profitability than companies with a broader scope. One explanation is that focussed companies have better chances to build unique capabilities and expert know-how to outperform competition. In conclusion, suppliers should focus on the extremes of the four plays: Either focus as a component supplier or engage in the system play.

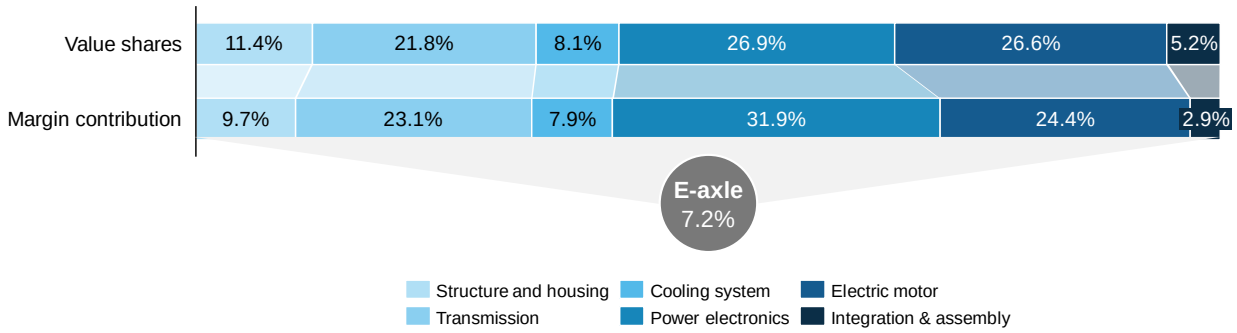

Figure 9: Weighted margin contribution for e-axles on sub-system level

Tailoring a specific offering is supported by a technology-focused margin-assessment for e-axles. As calculated in our bottom-up benchmarking, the inverter (as part of the power electronics) and e-motor account for more than 50% of total e-axle value – followed by the transmission, housing and thermal system. For each of these sub-systems, we have assessed typical supplier margins to understand the value-based margin contribution on system level. Combining value share and typical margin potential assessed from the analysis of more than 60 key suppliers, the inverter accounts for approximately one third of an e-axle's margin (see Figure 9). Transmission and electric motor account for another ~25% each, leaving the thermal system,

Power electronics dominate e-axle margin potential

housing as well as the contribution of integration and assembly far behind. In total, an indicative EBIT margin potential of 7.2% is expected for an e-axle with an annual production volume of 250,000 units.

Combining these insights with the OEM demand and technology differentiation potential analyses as presented before, a supplier can nail down on its strategic positioning. On demand side, our research suggests that especially the Global Premium and Volume OEMs are ramping up internal resources to build system know-how. In the short-term, this favours suppliers on component level. To win volumes with these OEMs, a supplier needs to be able to supply high volume components meeting the requirements of the newly established electrification platforms. In meeting this requirement, competences on system level can be an asset. The understanding is that any supplier needs to acquire a certain level of system know-how to successfully develop winning technology for electrification.

In the long-term, all OEM segments are expected to resort to purchasing on higher supplier integration levels as a state-of-the-art in e-axles technology has been established and volumes increase. Hence, the right timing is one of the critical parameters for a supplier's success. It is plausible that a supplier starts out with component supplies for the Global Premium / Volume OEMs as well as Local OEMs (Leader) and Product newcomers while developing integration and system know-how with Global Niche OEMs , Local OEMs (Follower) and Service newcomers.

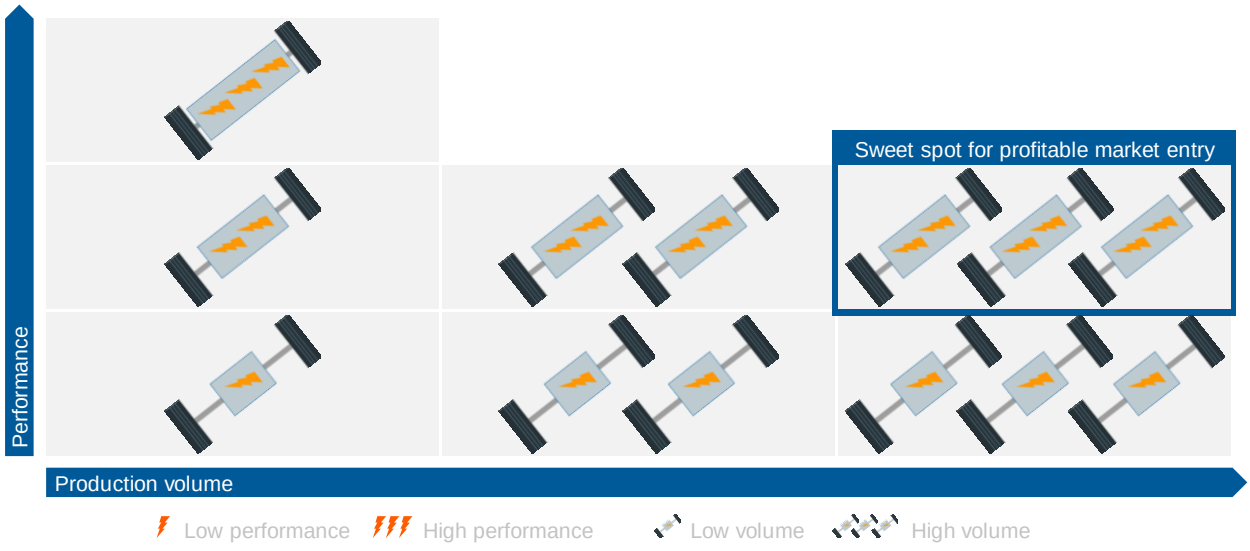

Figure 10: Economic viability of different e-axle projects based on performance and scale

Finally, it is the business cases originating from product positioning (scope and integration level), product specification (e.g. high vs. low performance) and targeted OEM segment (volumes) which define the right or wrong in e-axles for suppliers. For system level, Figure 10 shows the relationship between performance on the vertical axis and volume on the horizontal axis. The cross-section on business cases calculated by Strategy Engineers for multiple clients indicates that in most cases, currently only mainstream applications with high production volumes yield positive business cases - especially if a green-field approach is run for a single project. Any high performance or low-cost e-axle needs to rely on multiple projects to recover development and production invest.

In general, we refer to a mainstream e-axle in the range of 50 to 175 kW, designed for 300 to 450 V board nets. These can be used in BEVs or FCEVs as well as in parallel Hybrids (P4 architecture). Compared to this reference point, a low performance offering sees reduced product cost as requirements on all sub-systems are lowered. While there is the potential to go for high volumes with such axles (~35 kW at 48 V), no such combination is possible for high-performance axles (>225 kW at up to 800 V). For the latter, demand will be limited as only high-end models from Global Premium OEMs as well as high-performance cars from Global Niche OEMs provide suitable applications. There is however an increased margin potential for high-performance e-axles as advanced technological requirements (e.g. e-motor RPM or torque vectoring) need to be fulfilled. In addition, small volumes for high-performance products do hardly make a positive business case for in-house manufacturing at an OEM. This creates a window of opportunity for specialised system suppliers who can cater the needs of multiple high-performance applications based on a modular concept.

For single projects, only mainstream e-axles with high volumes yield positive business cases

For single series productions, we estimate a development time of three years. The business cases calculated for different e-axle projects suggest, that the cost accumulated during this time is hardly influenced by project scale or e-axle performance. It is hence the sales revenues which are critical in recovering the upfront investment. Along the product life cycle and including annual cost reductions requested by OEMs, only the high volume, medium margin e-axle (mainstream application) yields enough revenue to make a positive business case. Both a high volume but low cost and therefore low margin e-axle as well as a small volume high margin e-axle do not accumulate enough turnover to do so. At least not for a single project. In case multiple projects are considered and scales are achieved on a modular product offering, positive business cases can be possible in these niche applications. Successfully running multiple customer projects is a prerequisite for the in-house resources and capabilities of a system supplier.

Transformation: Required resources, capabilities & internal change

As summarised in the business case analysis, the strategic positioning of a supplier has direct impact on the required resources and capabilities of its organisation. The target offering needs thus to be enabled through organisational transformation.

Expert interviews conducted to acquire industry insights for this study suggest that suppliers considering either component or system play will have different starting points in electrification. For many hardware-driven suppliers, electrification is a new, technology-driven challenge. In contrast, electrics and electronics or software-based suppliers have access to a completely set of resources and capabilities while lacking hardware- and application-specific knowledge to enable integration. Their challenge is driven by industry and application.

Suppliers can resort to different strategic options to close potential gaps in resources and capabilities. For example, a supplier with core competences in controls and software or power electronics can add competences in e-motors and clutches through M&A activities. These could entail setting up a joint venture, partnering with another supplier or acquiring a specialised company. Another growth path represents a transmission supplier with core competences in differentials, transmissions and clutches who adds e-motor competences to enable an integrated offering. Depending on a supplier's starting point, there is a multitude of specific transformation paths.

Supplier organisations need to be transformed in order to efficiently develop and manufacture integrated systems

One central element of transformation for electrification business is the internal organisation. Especially if a supplier plans to integrate from a component play to system play, a suitable internal organisation needs to be put in place to deliver the e-axle project in time, cost and quality. From the perspective of resources and capabilities, choosing higher levels of system responsibility requires growing the set of competences regarding a supplier's organisation and processes, research and development as well as manufacturing.

		Capabilities			
	Supplier play	Development and validation	Manufacturing technology	Internal organisation	Process integration
	**System** ✓	●	◔	●	●
	**Sub-systems**	◕	◑	◑	●
	**Sub-assemblies**	◕	◕	◑	◑
	**Components** ✓	●	●	◔	◔

Figure 11: Required capabilities to build competitive advantage based on different supplier plays. A green arrow marks the economically viable plays

Building on the model of supplier plays, Figure 11 indicates which capabilities can be used to build competitive advantages. All items listed are additive, leaving the system supplier with the most comprehensive set of competences. While the component supplier can focus on core competences in, for example, highly specialised manufacturing processes for its components, a system supplier needs to run large scale assembly plants and operates a sophisticated cross-functional project organisation and is capable of vehicle integration.

Building on this example of a system play supplier, typical electric axle organisations start as projects bundling R&D and all other competences under a centralised project management. The key challenge for such a project inside an existing organisation is to establish processes and set up committed milestone plans. These are required to align all key functions that are not directly controlled by the project. However, this setup holds pitfalls regarding decision rights and responsibilities (e.g. budget). It should thus not be considered a permanent solution but a means to pull resources together and create critical mass inside the organisation.

As the offering gains traction on the market and multiple projects need to be handled, an “electric drive” division should be targeted as final state of organisational development. This can be set up as a profit centre integrating all required functions as well as components and has a dedicated manufacturing footprint for e-axles (see Figure 12).

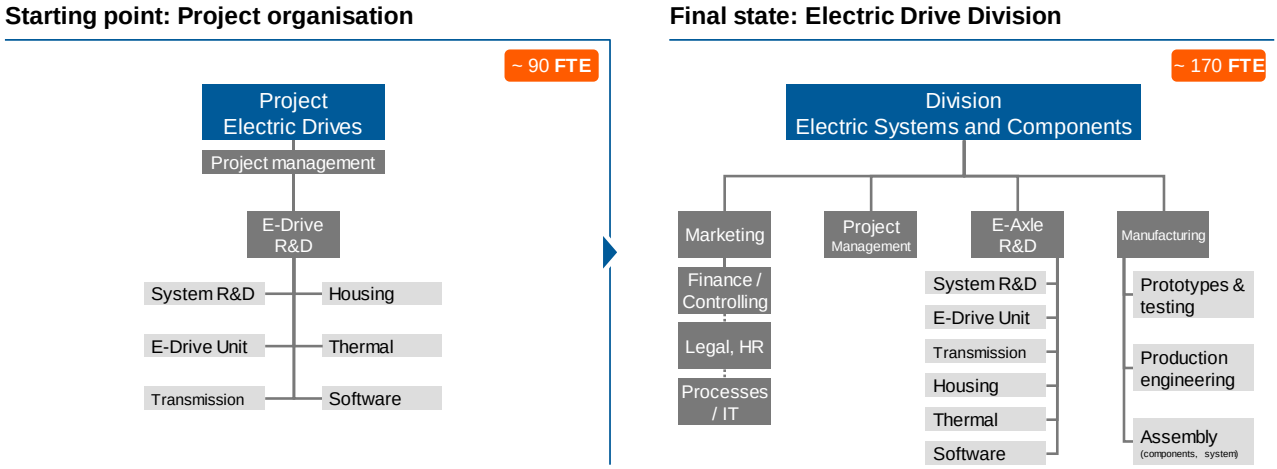

Figure 12: Proposed e-axle organisations depending on project maturity

The electric drive division also helps to break organisational silos and enable cross-functional support inside the supplier organisation. This requires rethinking organisational boundaries. While in the sub-assembly play, divisions with different components remain as independent businesses integrated by a project layer, the sub-system and system plays require medium and high levels of transformation and re-organisational effort. On sub-system play, customer units and a programme layer are required to enable application engineering for specific and parallel OEM projects. Even in case the resources on component level remain in the existing businesses and are integrated by a virtual project organisation, this encompasses new roles and responsibilities. Greatest change is required going for the system play where the major challenge is acquiring competitive system development capabilities and upgrade the organisation to hold the full range of required capabilities.

Conclusion

Electrification will come. And as a new state of the art in automotive propulsion technology is being developed, it will provide business opportunities for suppliers setting the stage now.

As electrified powertrains make their way from niche to mass market and replace conventional drive systems, the entire automotive industry is characterised by a high level of uncertainty. While Global Premium and Volume OEMs are trying to develop the required capabilities internally and largely source on component level, new entrants with new business models (Service newcomers) as well as Global Niche OEMs and Local OEMs (Follower) demand highly integrated and ready-to-apply system supplies. Supplier's product and technology offerings vary accordingly – opening room for innovation but also the threat of following the wrong roadmap or having the wrong timing. In the turmoil that electrification is causing, it is not only technology that changes, but also long-established relationships and positions along the industry's supply and value chains.

Matching the four supplier plays in e-axles with the seven OEM segments based on purchasing behaviour, it shows that for reasons of scale, value-creation potential and internal competences, only component and system supply are long-term positionings for suppliers. These two plays enable suppliers to successfully develop competitive

advantages and claim superior margins. To adjust their roadmap correctly, suppliers need to identify which are their key elements regarding both value and value creation for the system under investigation and identify how they can create competitive advantages. For an electric axle, highest margin potential is in power electronics while inverter, e-motor and transmission dominate product cost. Still – and in contrast to battery systems – the electric axle is not dominated by one single component regarding its value structure. In turn, there are three viable starting points to follow technologically reasonable integration paths from sub-systems to system. To unlock meaningful value creation potentials, suppliers must thus critically assess which integration path is most suitable for them.

In addition to the different growth paths available to suppliers based on their existing core competences and strategic targets, it is important to consider the demand side in finding the right market positioning. Automotive OEMs – especially in the Global Premium and Volume OEM segment – currently may not allow suppliers to capture system business. They are keen on developing the required competences in-house and need to find employment for their engineering and production teams. However, this trend is expected to reverse with increasing market maturity. Consequently, an e-axle's business case strongly depends on the targeted OEM segment as it determines supplier scope, scale, technology and ultimately margin potential.

Strategy Engineers business case analysis suggests that on system level, the winning combination is with a high-volume, mainstream application (50-175 kW at 300-450 V; BEV or P4 hybrid application) - at least with single projects for market entry. Further analysis provides that also multiple projects based on a standardised and modular design allow positive business cases for other applications such as low cost or high-performance e-axles. However, these increase the pressure on developing a scalable architecture while setting up the required internal organisation regarding processes, resources and capabilities. Electric drive systems ultimately require rethinking organisational boundaries.

The next generation of vehicles will decide the winning path of technology for electric drives. Now is the time for suppliers to seize the opportunities electrification is creating in the automotive industry.

Nomenclature

BEV	battery electric vehicle
E-axle	electrified axle
EBIT	earnings before interest and taxes
EU	European Union
EV	electric vehicle
FCEV	fuel cell hybrid electric vehicle
ICE	internal combustion engine
kW	kilo watt
MHEV	mild hybrid electric vehicle
M&A	merger and acquisitions
NAFTA	North American free trade association
NVH	noise, vibration and harshness
OEM	original equipment manufacturer
PHEV	plug-in hybrid electric vehicle
R&D	research and development
RPM	revolutions per minute
V	Volt
xEV	electric vehicle architectures, e.g. plug-in hybrid

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Strategy Engineers

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