KAISER ASSOCIATES

ELECTRIFICATION

AN OPPORTUNITY FOR OEMS AND SUPPLIERS TO POWER UP

PUBLISHED MARCH 2019

INTRODUCTION

As Kaiser continues our work throughout the Industrial Sector, few trends appear to have the wide-ranging impact that electrification is having on our clients.

As industrial machinery moves from combustion energy to electric, significant disruptions are occurring to OEMs and their supply chain that has remained relatively stable for 70 years.

Many industrial manufacturers are comforted by the fact that electrification is a slow-moving trend, subject to the 10 –20 year lifecycles of most industrial products. While that may be historically true, we believe that electrification is set to rapidly accelerate in the next 5 – 10 years. Manufacturers that are researching, planning, and piloting *now* will be well positioned to capture the changing market, while those that are in *'wait and see'* mode may be left behind.

In the following pages, we explore the drivers of electrification, noting their sustainability now vs. in previous years. We then provide trends and an initial sense of opportunity size in key segments. Finally, we offer high-level strategies for both OEMs and suppliers to best position themselves for success in this new environment.

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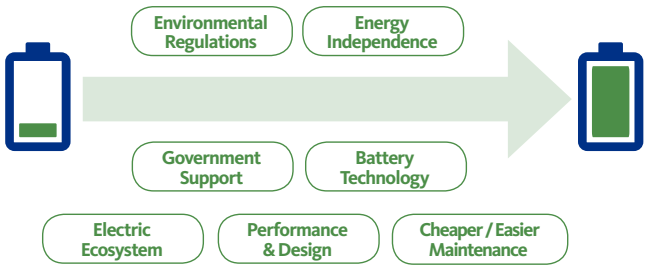
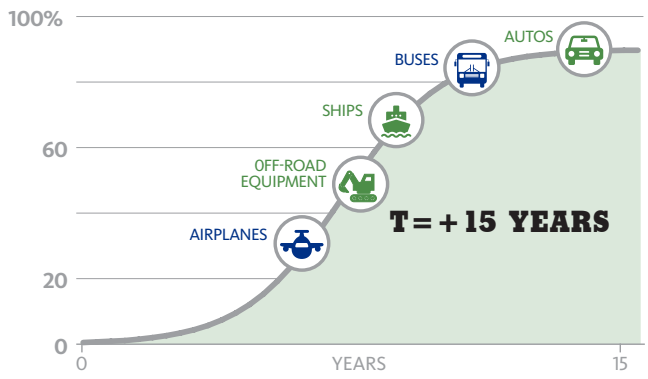
Drivers of electrification are building momentum...



...driving OEMs up the electrification maturity curve...



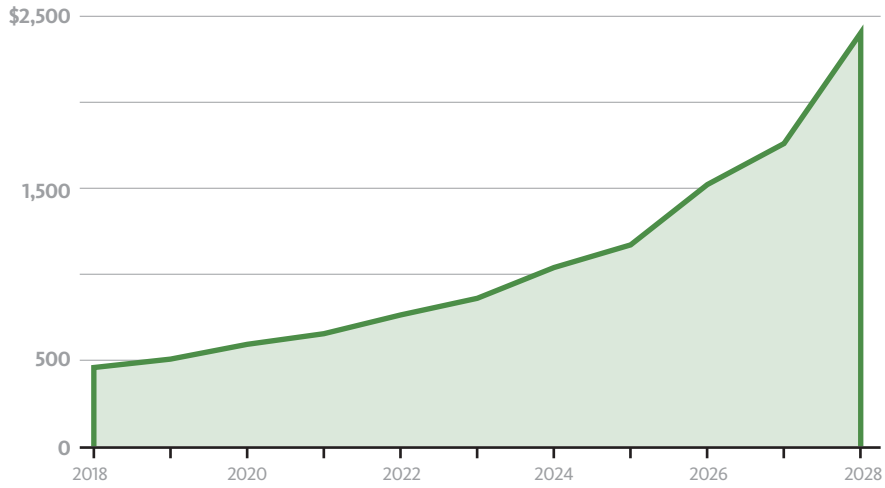
RECOMMENDATIONS FOR OEMS

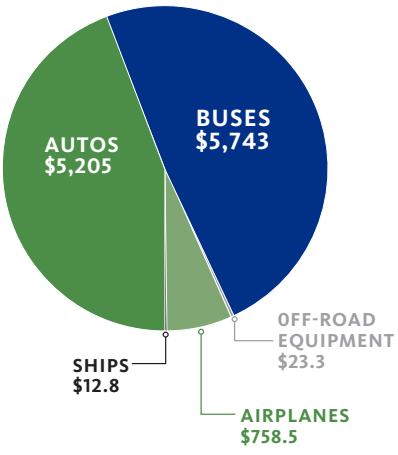
- **Leverage partnerships** to support product development, reduce costs, reduce risk, increase speed-to-market and improve operational efficiencies
- **Change your business model,** especially your go-to-market strategy given electric equipment is not yet at price parity with ICE equipment; consider new leasing models
- **Revisit your sourcing strategy and talent agenda** to drive greater electrification
- **Adapt your brand** to embrace electrification and its benefits from a consumer perspective

RECOMMENDATIONS FOR SUPPLIERS

- **Understand OEM priorities** through voice of customer research, so you can quickly position yourself to be the key supplier for new, electric products
- **Get in early,** particularly if your customers have long product cycles; connect directly with customer R&D teams
- **Incorporate electrification into your product roadmap** now to avoid obsolescence or being surprised by new competitors
- **Develop new competencies** through M&A or partnerships, particularly in material design and electrical engineering
- **Manage resources** effectively to balance R&D spend and continuing to improve operational efficiencies to sustain profitability

...creating a large market opportunity *(figures in billions of dollars)*





Several underlying trends are causing OEMs to rethink how electrification plays into their longer term growth strategies

THIS TIME IT IS REAL: DRIVERS OF ELECTRIFICATION

The fundamental change caused by electrification is costly, but OEMs across key segments are actively investing. This is due to government, societal, and technology drivers converging at a single moment, creating a true market opportunity.

Additionally, the trends noted below have successfully created enough momentum to allow market forces to continue developing the opportunity without external intervention. Already, U.S. corporate investments in electrification continues as the Trump Administration has refocused on conventional energy sources and industries, indicating electrification is not solely dependent on U.S. government support – it is both global and now driven by the market.

IMPROVING BATTERY TECHNOLOGY

Improvements in materials, processes, and cell design have driven battery costs down from ~$1,000 per kWh in 2010 to ~$200 per kWh in 2017. As technology costs have fallen and adoption rates risen, a new wave of investment has emerged, driving the development of the next generation of batteries. In addition to costs, concerns over driving range or 'range anxiety' have faded. Increased energy density has enabled drivers to complete nearly 80% of daily trips.

However, energy density remains a key obstacle in other modes of transport. Boeing, whose venture arm took a minority stake in Cuberg, is seeking to develop batteries that could drive propulsion. According to Steve Nordlund, vice president of Boeing HorizonX, "Cuberg's battery technology has some of the highest energy density we have seen in the marketplace, and its unique chemistries could prove to be a safe, stable solution for future electric air transportation."

BROADER AND MORE DEVELOPED ELECTRIC ECOSYSTEM

As consumers drive longer distances, the need for large-scaling charging stations becomes more inherent. According to David Finn, CEO and co-founder of Tritium, a power electronics engineering company, "when you start to move in to that 2, 3, 4 percent market penetration you start to get more of the early adopters, and they are going to be more demanding in terms of flexibility."

Today, ~80% of electric automobile charging occurs in residential settings, where owners can take advantage of favorable electricity rates. Unlike refueling an ICE automobile, electric charging is slow. Government funding of DC fast charging stations can broaden the electric ecosystem, not only accelerating charging times, but making interstate travel easier and safer, while driving adoption rates higher. As demand for electric-powered vehicles increases, the electric ecosystem will expand beyond automobiles, to support electric buses and ships.

PROVEN IMPROVEMENTS IN PERFORMANCE AND DESIGN

Electric automobiles offer better maneuverability, controllability, and drivability than ICE automobiles, and eliminate idling. Electric buses and ferries generate less noise, providing a more comfortable transit experience. More electric aircraft (MEA), like the Boeing 787 and 350, are lighter and more fuel-efficient, generating greater cost savings. Electric off-road equipment helps mining operations run easier, safer, and more profitable by reducing the demand for costly ventilation systems. According to Jay Armburger, a product manager at Caterpillar, "our customers are planning for deeper mines with very high ambient rock temperatures, where ventilation costs are pivotal to making the mine viable. One means of reducing ventilation demand is through electrification of mining equipment."

In addition, electric powertrains enable engineers greater freedom and flexibility with product design. As prices decline and reach parity with ICEs, purchasing decisions will become less centered around price and more focused on performance and design. Both OEMs and suppliers will need to understand end users' drivers of choice.

Electrification is not solely dependent on U.S. government support –it is both global and now driven by the market

CHEAPER AND EASIER MAINTENANCE

According to researchers at the University of Michigan, electric automobiles are 50% more cost-effective than gas-powered automobiles. Electric-powered engines are much simpler mechanically, drastically reducing the risk of any major overhauls. Electric vehicles also require fewer fluids and brake systems typically last longer due to regenerative braking. Additionally, electric vehicles allow for better data collection and reporting due to telematics, helping keep maintenance in check. As demand for travel and equipment usage increase, lower maintenance intervals become more important, as the cost of downtime increases. Both owners and operators become more willing to pay the higher upfront cost for electric vehicles due to the higher level of reliability and lower cost of maintenance.

INCREASING ENVIRONMENTAL REGULATION

According to the Lancet Commission, air pollution is the fourth-highest leading cause of death, contributing to 6.5 million deaths globally. Governing bodies are enacting more stringent regulations to improve air quality. In China, government officials have announced plans to phase out the sale of ICE vehicles, in parallel with new policies to promote the sale of electric vehicles. In Europe, the EU has already agreed to a 40% reduction in greenhouse emissions by 2030 compared to 1990 levels. Several countries, including Norway (2025), the U.K. (2040), and France (2040), have announced plans to ban sales of new petrol and diesel cars and vans. In the U.S., new Corporate Average Fuel Economy (CAFE) standards have rolled-out, requiring automakers to raise fuel efficiency standards of new cars and trucks by 2025.

GREATER GOVERNMENT SUPPORT

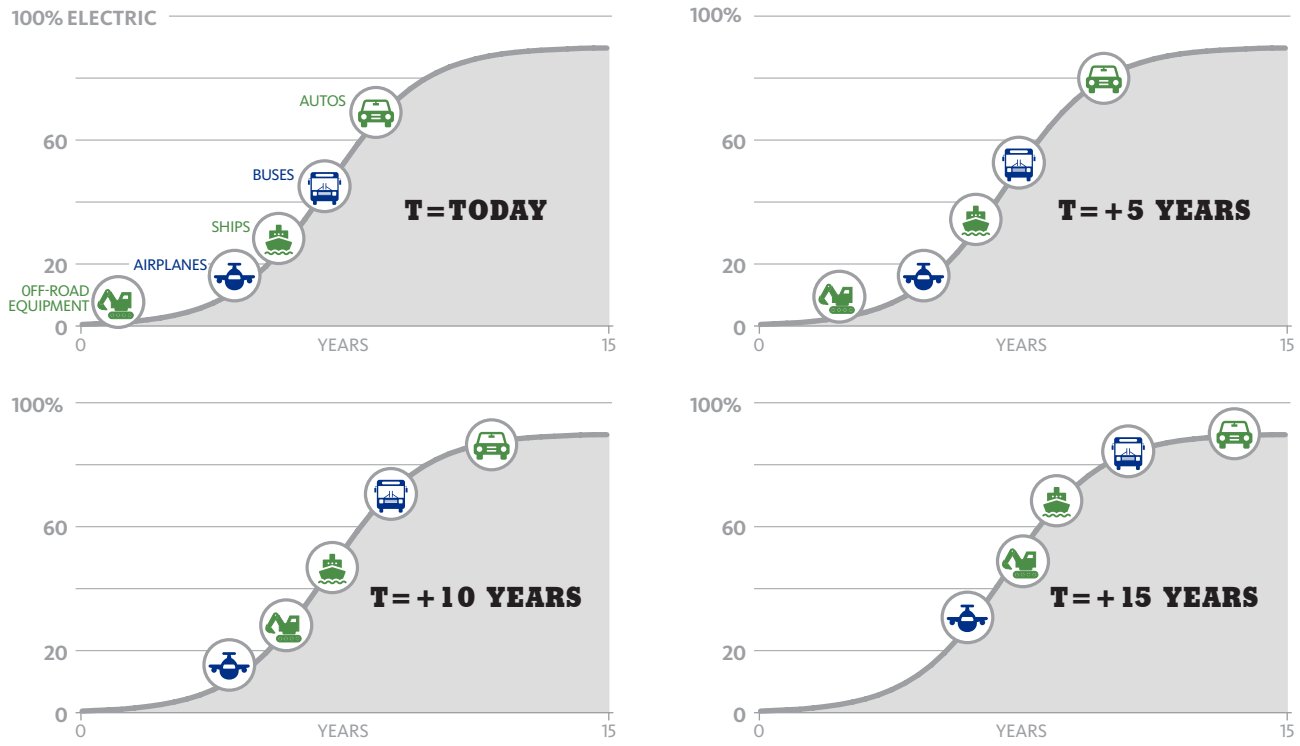
In addition to enacting more stringent environmental regulations, governing bodies are providing direct business support via subsidies, sales quotas, and consumer incentives. China became the world's largest electric vehicle market partly due to subsidies and recently mandated that global automakers comply with new cap-and-trade emission rules starting in 2019, whereby manufacturers that sell more than 30,000 automobiles are required to meet a sale quota of 10% being a plug-in hybrid or all-electric battery. In the U.S., electric vehicle adoption has been partly attributed to consumer incentives. Federal tax credits have helped offset some of the upfront costs, while several states and local utilities have offered consumers additional incentives, such as rebates, tax credits, and non-cash incentives.

While direct business support and consumer incentives have been critical, both China and the U.S. are considering rolling back some of these incentives. According to Li Yixiu, sales chief for Beijing Electric Vehicle Co., China's largest manufacturer of electric automobiles, "government policy has a huge impact over the new-energy vehicle sector and every adjustment made on the policy front over the next two years will result in tremendous changes in the industry."

GROWING IMPORTANCE OF ENERGY INDEPENDENCE & DIVERSIFICATION STRATEGY

Many countries are prioritizing energy independence and diversification as part of a broader national security imperative, reducing exposure to supply disruptions and price fluctuations. In 2017, U.S. net imports of petroleum from foreign countries were equal to ~19% of U.S. petroleum consumption, its lowest percentage since 1967. Continued government support for electric vehicles will help reinforce this strategy, mitigating some of the threats associated with macro shocks. Additionally, technological advances have made renewable energy sources less cost prohibitive, leading to greater investment and adoption, and will be key to supporting energy independence strategies. According to Chris Beam, president of Appalachian Power, "this is probably the fastest changing dynamic (shifting energy sources used for power generation) that we have seen in the power industry in probably the last 100 years." This shift in power generation is enabling downstream electrification.

Average Level of Equipment Electrification *(% electric per unit)*



EARLY INNINGS OF ADOPTION

The push towards electrification is being driven by several converging trends, but it is the advancements that have been made in battery technology that have accelerated viability and adoption, particularly in automobiles, where cost and energy density make it competitive with ICEs. According to Bloomberg New Energy Finance, there were 1.1 million electric automobiles on the road in 2017 globally and is forecasted to grow to 11 million by 2025. Automobiles are by far the most adopted and technologically advanced electrical vehicle in-use today. Adoption is expected to grow exponentially, with some experts predicting that by 2025, 25% of automobiles sold will have electric engines. As batteries evolve and become smaller, more energy dense, and cost-effective, its application becomes more appealing for other modes of transport.

Following automobiles, buses are the next most common mode of transport to utilize batteries given their fixed travel routes. Today, ~99% of world's electric buses can be found in China, where the government has implemented policies to incentivize OEMs to manufacture and provinces to purchase electric buses, in a concerted effort to reduce smog and congestion. As battery costs continue to decline and driving range and performance increase, more and more cities will make the switch to electric buses.

Larger modes of transport, such as ships and airplanes are years, if not decades away from viable, commercial scale. Due to the sheer power requirements, as well as weight and cost, electric propulsion is not currently a viable alternative. That said, a small segment within the shipping industry, small barges and water taxis, are well-suited for electric propulsion, given their short, fixed travel routes, like buses. OEMs are concurrently beginning research into electric propulsion, while replacing traditional pneumatic and hydraulic systems in new aircraft with electrical systems, shedding weight and helping airplanes run more efficiently.

Lastly, OEMs are beginning to invest in electric off-road equipment, developing new prototypes for the market. Outside of aerial work platforms (AWPs) and telehandlers, very few electric equipment is available commercially. Unlike automobiles, buses, ships, and airplanes, off-road equipment is designed to travel and provide various levels of functionality, limiting the ability to fully electrify the equipment. This requires different engineering and power requirements, as well as performance standards, which will take OEMs some time to develop.

While off-road equipment is currently lagging, we expect that, over time, off-road equipment will be more electric than aircrafts as the technological requirements towards fully electric equipment are significantly lower than airplanes or ships.

Automobiles

While electric automobiles represent only ~1% of automobiles on the road in the U.S., adoption is expected to rise rapidly. Increasing environmental regulation, greater government support, and advances in battery technology have been the primary factors driving sales. In China, which surpassed the U.S. to become the largest electric vehicle market in the world, government policy has been the underlying driver for electric vehicle growth. According to Bloomberg, the government has spent ~$9 billion to finance the purchase of new energy vehicles between 2009 and 2015 and is calling for the production of 2 million electric automobiles annually by 2020 and 7 million annually by 2025. In the U.S., electric vehicle growth has been spurred by government policy, such as emissions and fuel efficiency standards, as well as consumer incentives. Battery costs, which have been the primary driver of electric automobile costs, are expected to fall due to economies of scale. Despite a higher upfront cost, electric automobiles offer a lower total cost of ownership.

OEMs have responded by shifting their product development and R&D efforts towards the development of hybrid and electric vehicles. According to one executive at a start-up electric vehicle company, "there are three contenders for this huge market opportunity (electric vehicles). The first is the OEMs. But they had to learn from Tesla how to do it." According to Reuters, big auto has committed $90 billion to electrify some of its most popular automobiles over the next several years. In addition, a slew of well-capitalized starts-ups, such as BYD, Karma Automotive, Fisker, and NIO are competing to disrupt the automotive industry and become the leaders in electrification race. According to Padmasree Warrior, head of the U.S. arm of NIO, "Tesla paved the way, now we're taking this a step further. We have a mission to transform mobility." Given the high, upfront R&D costs, as well as long product development cycles, both suppliers and OEMs view increasing environmental regulation as a longer-term trend.

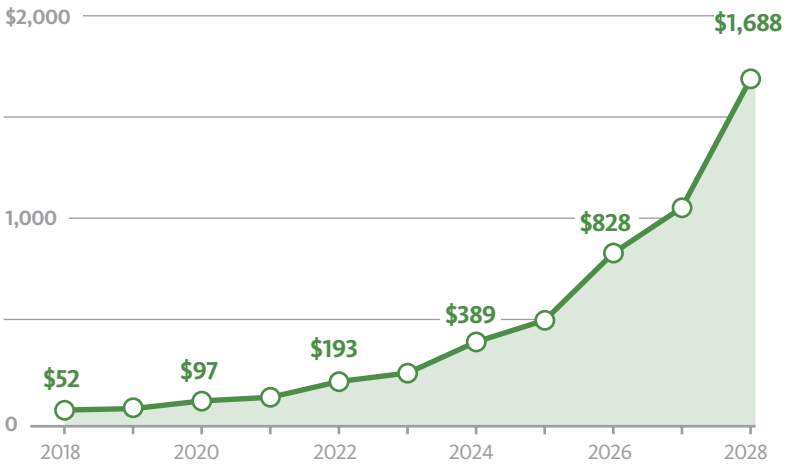
Kaiser estimates that the 2018 global market for electric automobiles is $52 billion and is expected to grow at a 60% CAGR through 2028, to $1.7 trillion.

According to the International Energy Agency, the number of battery electric automobiles on the road is expected to grow from 1.1 million in 2018 to 130 million in 2030. Continued government support, as well as battery cost reductions will drive rapid adoption. In China, government subsidies will help electric automobiles grow to nearly 25% of the market, while in Europe, more stringent emission standards and high fuel taxes will drive sales. In the U.S., growth appears strong, especially in states with zero emissions plans, like California, but could be hindered by the Trump administration's efforts to restrict vehicle emission standards.

While the adoption of electric automobiles is expected to accelerate, adoption will be impacted by several factors, including price, ability to mitigate range anxiety concerns, and access to charging infrastructure. Electric automobiles are not expected to reach price parity with ICE automobiles for another 5 – 7 years. As a result, consumers may not be swayed to purchase an electric automobile, despite the lower total cost of ownership, without incentives (e.g., tax credits and rebates). Continued government support will be a key catalyst to drive adoption until price parity is reached. Advances in energy density have led to longer driving range, allowing end users to complete most trips under a single charge. However, OEMs and suppliers must continue to invest and develop longer lasting batteries to compete with ICEs. This is especially true as end users look to travel further distances without concerns of having to stop and charge or find a charging station. While the number of charging stations has and is expected to grow exponentially, there is still a significant gap between the number of electric charging stations and gas stations, and thus range becomes a more pressing concern while infrastructure is developed.

Global Market Size for Electric Automobiles

(figures in billions of dollars)



Buses

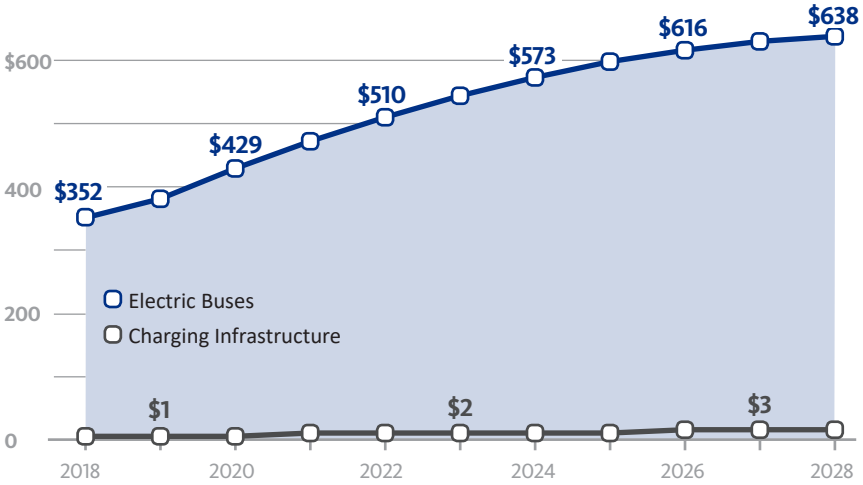
~50% of global municipal buses will be electric, according to Bloomberg New Electric Finance, within the next decade. Increased urbanization is driving the need for electrification, as cities look to curb emissions and traffic congestion. Conventional buses consume up to four times more fuel than the average automobile. Older generation buses, which primarily utilize diesel fuel, are high emitters of pollutants and smog. For example, in Shenzhen, buses represented 0.5% of the vehicles on the road but contributed to nearly 20% of the city's air pollution. By switching to electric buses, the city noticed immediate improvements in air quality and realized significant savings from fuel and maintenance expenses. In addition, the city now offers a greener, more reliable, and quieter public transportation option. Other large European cities, such as London and Paris, are beginning to follow suit. In the U.S., states such as Illinois and New York, are setting aside funds from Volkswagen's $2.9 billion diesel-scandal settlement to fund electric school buses, which nationally number in the hundreds. In White Plains, New York, National Express purchased five electric school buses with help from state grants and formed a partnership with Consolidated Edison, in exchange for the utility to use the buses to help store and discharge energy during the summer months. Officials believe that this partnership could serve as practical way for utilities to help finance electric school buses across the state.

Kaiser estimates that the 2018 global market for electric municipal buses is $351 billion and is expected to grow at a 6% CAGR through 2028, to $635 billion. China is expected to see electric bus volumes nearly triple from 482,118 to 1.4 million over this timeframe, as the government continues to pursue its efforts to improve air quality and become the largest exporter of electric buses. In Europe, electric municipal buses are expected grow 17-fold, as new emissions regulations e.g., Euro 6 serve as a catalyst for adoption. In the U.S., the growth outlook appears more subdued due to falling transit ridership, as well as growing concerns over battery technology and vehicle performance. Given the robust global outlook, demand for charging stations is also expected to surge. Kaiser estimates that the market for charging infrastructure will more than triple from $968 million in 2018 to $3.0 billion by 2028.

While the outlook for electric buses remains promising, concerns still linger around its costs and driving range. Electric buses can cost upwards of $200,000 – $300,000 more than diesel or natural-gas powered alternatives, excluding the costs associated with charging infrastructure. While operators recoup this difference (and more) over the life of the bus through fuel and maintenance savings, some municipalities have cited the upfront costs as a significant barrier to overcome. Others are skeptical over the reported driving range, citing concerns that the buses are less reliable and unable to meet the busy schedule. In Los Angeles, city officials claim that newly purchased electric buses did not meet expected range targets, while three school districts in Massachusetts claim buses had repeated battery and software failures, leading to lengthy repair cycles. Additional concerns have been raised surrounding driving performance, particularly in colder geographies, where range can drastically fall as batteries degrade and the use of heaters drain additional power. Many of these concerns have been dispelled as battery density has improved.

Global Market Size for Electric Municipal Buses and Charging Infrastructure

(figures in billions of dollars)



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Ships

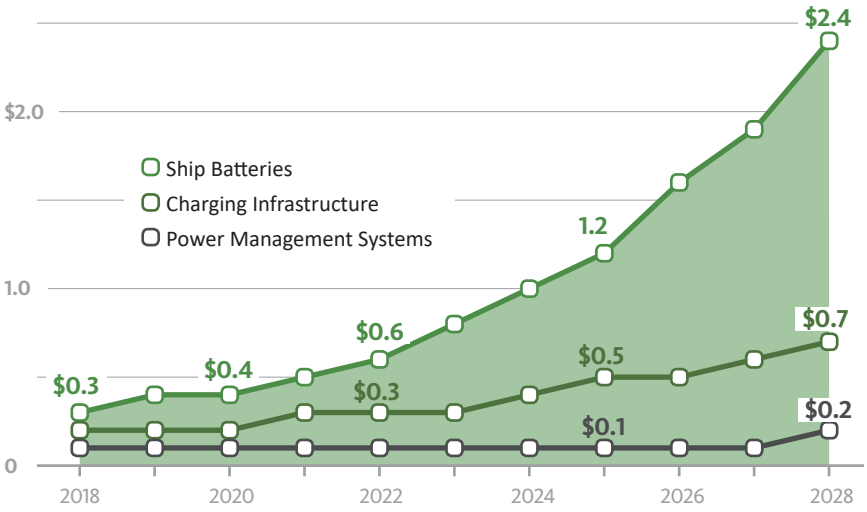
Due to increased globalization, over 90% of goods travel at some point by ship. Ships primarily utilize a highly pollutant fuel, bunker fuel, and are responsible for ~2% of global emissions. In 2016, the International Maritime Organization (IMO) mandated that ships reduce their sulfur oxide emissions from 3.5% to 0.5% by 2020. Vessels are faced with the difficult decision of switching to more expensive, but lower sulfur distillate fuels or installing scrubbers to strip out emissions from the more pollutant bunker fuel. While current battery technology is unable to meet the high-power needs for larger ships, smaller vessels, such as ferries, water taxis, and barges, are well-suited for adoption. Electric ferries are 30-40% more expensive than diesel-powered ferries but offer operators a lower cost of ownership, with reported fuel costs savings upwards of 70 – 80% and payback within 3 – 4 years. In addition, electric propulsion generates significant noise and wave reductions, bringing important environmental benefits to wildlife and people along routes.

Kaiser estimates that the 2018 global market for ship batteries is $337 million and is expected to grow at a 22% CAGR through 2028, to $2.4 billion. The two largest battery suppliers in the industry, Corvus and Plan B Energy Storage have seen double digit growth over the last several years, while larger conglomerates such as ABB and Siemens are looking to grow share. Much of this growth is being driven by Northern Europe, where governments are enacting environmental policies aimed at combatting climate change, as well ferries being the fastest and most cost-effective means to carry passengers from small islands to the coast. In Norway, the country's entire vessel of ferries will be all-electric or equipped with hybrid technology for longer routes by 2023. Power management systems, which help distribute electric power and secure power for propulsion and maneuvering, are expected to more than double from $60 million in 2018 to $158 million in 2028. Onshore charging stations will be installed at both ends of the route, with ferries plugging in at each of the docks as passengers and vehicles disembark. Kaiser estimates that the market for charging infrastructure will grow 7-fold from $192 million in 2018 to $714 million by 2028.

Short sea travel represents a tiny fraction of the world's shipping fuel consumption, with container ships, tankers, and bulk carriers using the most. The adoption of electric propulsion for longer sea voyages is still some years out, as the sheer weight and size of the batteries required to meet power demands are prohibitive. Battery range will continue to serve as a severe limitation for transoceanic voyages. Until technological breakthroughs are made, larger freight and cargo ships will switch to liquified natural gas (LNG) powered engines in the interim, which emit significantly less pollutants, meet IMO standards and generate significant fuel cost savings.

Global Market Size for Ship Batteries, Charging Infrastructure, and Power Management Systems

(figures in billions of dollars)



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Airplanes

According to the International Air Transport Association (IATA), the number of passengers traveling by air is expected to nearly double to 7.8 billion by 2036. To optimize performance and reduce operating and maintenance costs, airlines are moving towards more electric aircraft (MEA). Systems that were once powered by pneumatics and / or hydraulics are now being replaced by electricity, reducing aircraft weight, fuel consumption, and emissions. Aircraft manufacturers like Boeing and Airbus have already begun replacing some pneumatic and hydraulic powered systems with electricity in newer airplanes e.g., power environmental control systems (Boeing 787), flight control systems (A350), wheels and brakes (Boeing 787), and thrust reversers (A350).

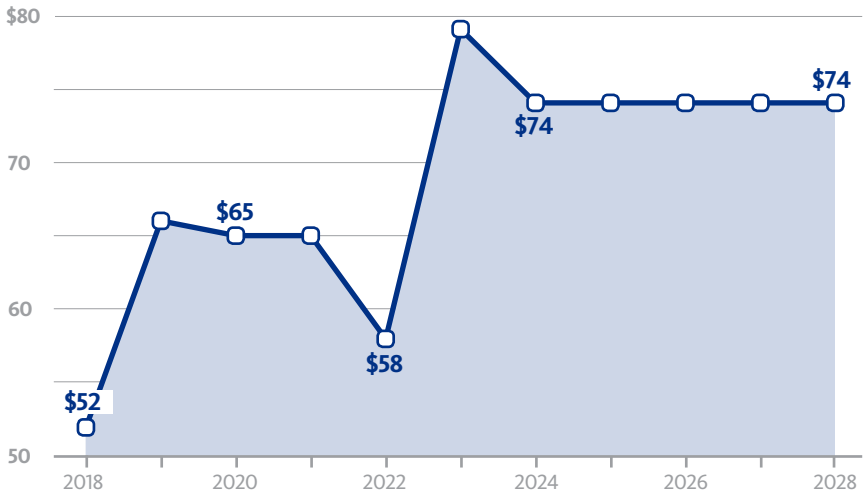
While the airplane industry has historically been concentrated across a select number manufacturers (e.g., Boeing, Airbus, Embraer, Bombardier), many new start-ups are beginning to emerge. Zunum Aero, which is backed by Boeing and Jet Blue Ventures, is aiming to disrupt regional travel by developing a hybrid-electric propulsion airplane that offers 40 – 80% lower operating costs than those of regional aircraft today. The company is scheduled to deliver its first hybrid-electric plane to JetSuite in 2022.

Kaiser estimates that the 2018 global market for electrical systems in airplanes is $52 billion and is expected to grow to $74 billion. While production rates for the Boeing 787 and A350 aircraft are expected to level out then decline by 2022, the next generation of new, MEA aircraft will be unveiled. According to Boeing, over 42,000 airplanes will be required over the next 20 years to meet commercial demand, with single-aisle airplanes comprising the majority (~31,000). According to Safron, the electrical systems in an all-electric, single-aisle commercial jet account for 8 – 10% of its total value.

While MEA continues to grow, most aviation experts believe that electric propulsion at a commercial scale will not be viable for at least a decade. Existing batteries do not offer the right power-to-weight ratio for electric propulsion to be feasible and energy density is not sufficient to get airplanes off the ground. Electrical storage systems need an energy density of at least 500 Wh/kg and the highest commercially available batteries range from 150 – 320 Wh/kg. Moreover, even when batteries attain this level, the energy storage density will still be a factor of 25 less than that delivered by jet fuel. Lastly, the use of batteries has only deepened public safety concerns following the FAA's grounding of the Boeing 787 in 2013 after several incidents of batteries catching on fire were reported. While Boeing implemented several changes that resolved the issue, public perception over the safety of batteries has not changed.

Global Market Size for Electrical Systems in Airplanes

(figures in billions of dollars)



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Off-Road Equipment

The vast majority of equipment found on construction and mining sites are diesel-powered, but new emissions standards e.g., Tier 4F, EU Stage IV / V, and China III, are paving the way for OEMs to develop electric-powered equipment.

Caterpillar and Pon Equipment recently partnered together to develop an electric excavator that can operate up to seven hours on a single battery charge. Electric equipment like the 323F not only eliminate dangerous pollutants, but generate significant noise reductions, allowing construction crews to operate in more sensitive urban settings, where city ordinances have set maximum noise levels and restricted the times during which construction noises can exceed this threshold. In addition, crews are able work longer hours, allowing construction to take place during non-peak hours, reducing the burden on roads during rush hour.

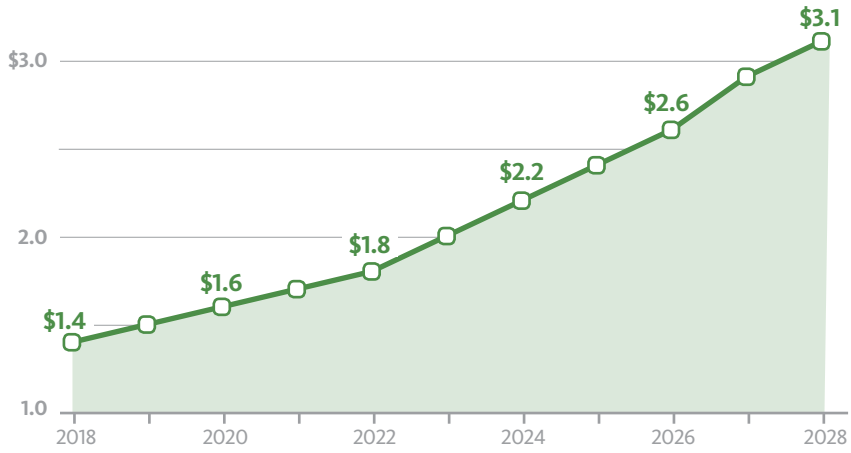
The mining industry also faces its own unique set of challenges. New reserves are increasingly in short supply, with companies being forced to excavate deeper underground in existing mines. As operations move further underground, mines are forced to run large-scale ventilation systems to maintain worker safety. These systems are extremely costly, representing the bulk cost (~30%) of the underground operations. Caterpillar is currently in the process of developing an electric load/haul/dump (LHD) prototype to reduce the demand for surface infrastructure.

Kaiser estimates that the 2018 global market for electric off-road equipment is $1.4 billion and is expected to grow at a 9% CAGR through 2028, to $3.1 billion. OEMs are in the early stage of developing electric prototypes. Volvo will be testing its hybrid wheel loader and cable-connected excavator in partnership with Skanska at a quarry in Sweden later this year. The jump to all- electric is still 10 – 15 years away and hybrid equipment will serve as a bridge to complete electrification.

Unlike cars and buses, off-road equipment performs many different functions e.g., lifting, loading, and drilling which require higher outputs of energy. Aerial work platforms (AWP) utilize batteries to drive hydraulics, but have yet to drive propulsion. To support this functionality, off-road equipment will need to shed weight, but not at the expense of performance, where the ability to operate in harsh working conditions is key and the cost of downtime is high. Batteries for non-compact equipment, such as excavators are price prohibitive and cost more than the equipment itself. Lastly, equipment is often times utilized on remote job sites that do not have direct access to electricity, requiring sites to develop their own grid with storage capabilities.

Global Market Size for Electric Off-Road Equipment

(figures in billions of dollars)



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HOW OEMS SHOULD RESPOND

While electrification is still nascent in many industries, OEMs can better position themselves for long-term growth by taking the following steps:

CHANGING PRODUCT DEVELOPMENT PROCESS

OEMs should evaluate the role electrification will play in current and future products, technological capabilities and limitations, supply chain, factory and assembly line structure, and workforce.

LEVERAGING PARTNERSHIPS

OEMs ability to create partnerships with a variety of partners will be crucial to support product development, reduce costs, and improve operational efficiencies. For example, DEUTZ recently partnered with Manitou Group to develop electric and hybrid drive systems for construction telehandlers, resulting in its first full electric construction telehandler prototype. Leveraging these types of partnerships will help OEMs create value for customers.

CHANGING BUSINESS MODELS

OEMs will need to adjust their go-to-market strategy given that electric vehicles are not at price parity with ICE vehicles. Given the higher upfront costs, OEMs must employ creative strategies to help ease this upfront burden. BYD for example, launched a leasing program to reduce upfront costs, broadening access and appeal.

ADAPTING BRAND

OEMs should adapt their brand to embrace electrification and appeal to younger consumers. Millennials, which represent the largest segment of consumers, identify with products and services that solve real-world problems, have a pro-social message, and possess an 'it' factor. Brands that are better able to resonate with young people's values will be more likely to succeed in the future.

DOWNSTREAM IMPACTS

Electrification is shifting the mix of components found in vehicles. OEMs are more intent on employing more electric systems. As a result, mechanical, hydraulic, and pneumatics systems and components are becoming more obsolete and commoditized. OEMs are shifting focus to assembly, outsourcing the development of systems that were once developed in-house, and streamlining the entire supply chain, reducing the number of vendors.

KEY RECOMMENDATIONS FOR SUPPLIERS

Electrification is drastically changing the dynamics of the supplier-OEM relationship. For suppliers to thrive in this environment, they must:

UNDERSTAND THE PRIORITIES OF OEMS

Suppliers should conduct voice of customers studies to understand OEMs' priorities (e.g., weight, cost, or efficiency), better positioning themselves to serve OEMs for the foreseeable future.

GET IN EARLY

Many industries operate on lengthy product development cycles, where commercial production can be decades out. It is critical for suppliers to begin working with OEMs on R&D as early as possible. First movers can design themselves into the supply chain, displacing traditional suppliers, and establishing a highly defensible market position.

INCORPORATE ELECTRIFICATION INTO THE PRODUCT ROADMAP

Suppliers should assess their existing product portfolio to determine the risk of obsolescence. Evaluating competitive advantages and technical competencies will go a long way toward helping determine product development capabilities. Suppliers should also consider conducting commercial due diligence to identify market potential for products, helping suppliers determine attractiveness of opportunities.

DEVELOP NEW COMPETENCIES

Suppliers must develop new competencies beyond their existing capabilities, whether organically or through M&A and partnerships. In addition, they must shift away from their mechanical roots and develop domain knowledge in advanced material design and electrical engineering. HR will be key to talent management, identifying new talent and retaining key employees with the skills set necessary to support the new product roadmap.

MANAGE RESOURCES

Suppliers will need to balance increasing R&D spend to support new product development, while continuing to improve operational efficiencies with current technologies to sustain profitability.

For a list of sources and works cited, please visit our website.

KAISER ASSOCIATES

ELECTRIFICATION

AN OPPORTUNITY FOR OEMS AND SUPPLIERS TO POWER UP

PUBLISHED MARCH 2019