Copper Development Association Inc.
Copper Alliance

The Road to Sustainable Mobility Is Paved with Copper

An automobile needs a source of energy. That energy source, since the earliest days of the automobile industry, has been the controlled combustion of hydrocarbons. Now, electric batteries are seriously challenging the supremacy of the internal combustion engine (ICE).

The electric vehicle (EV) as it exists today represents the biggest paradigm shift in the automobile industry since its beginning more than 100 years ago. Aside from the excitement that it sparks amongst automotive enthusiasts, the rediscovery, advancement and ultimate success of EVs has enormous consequences for the copper industry.

Wherever electricity is put to practical use, copper is key.

Not surprisingly, when compared to a conventional vehicle, an EV typically contains more copper by weight[1]. While conventional cars contain roughly 20 to 50 pounds of copper, a hybrid electric vehicle (HEV) typically contains 85 pounds of copper; a plug-in hybrid electric vehicle (PHEV) uses about 130 pounds of copper; and battery electric vehicles (BEVs) typically contain more than 180 pounds of copper. Moreover, a hybrid electric bus contains 196 pounds copper, and a single battery electric bus contains a whopping 814 pounds of copper. In the latter case, most of the copper is used in the battery.

Over the course of the past three decades, EV technology has steadfastly advanced. Its status has evolved from a dream to a distinct possibility, and now, a practical reality. Many of those advances have been in the ways copper is put to use.

Copper is essential for the efficient performance of all types of electric vehicles. For example, a pure electric vehicle might contain more than a mile of copper wiring in its stator windings. Besides its use in electric motors, copper is used in batteries as well as the inverters and wiring. Copper is also used in charging stations. The reason copper is used in these applications is because of its unmatched combination of durability, malleability, reliability and superior electrical conductivity.

A Forgotten Technology

For much of the twentieth century, electric vehicle technology stagnated. It was a forgotten technology.

It may come as a surprise that the EV was competitive with the internal combustion engine at the dawn of the "horseless carriage" age. A six passenger EV carriage with a top speed of 14 mph was built and marketed by William Morrison in the United States around 1890. A decade later, electric cars were at their heyday, accounting for around a third of all vehicles on the road, and they continued to show strong sales for another 10 years.

Yet, for better or worse, advances in engine technology, mass production and cheap fuel favored the emergence of the internal combustion engine as the dominant technology, and electric car sales faltered in the marketplace. As the ICE advanced, EVs were soon forgotten.

Rising energy costs in the sixties and seventies and concerns about the environment in the nineties sparked renewed interest in EVs but, by then, EV technology lagged so far behind ICE technology that it was difficult to catch up. Finally, from 1996 to 1999, General Motors produced and leased the "EV1" as the first mass-produced electric vehicle of the modern era. The EV1 developed a cult following but ultimately failed in the marketplace as described in the 2006 documentary film "Who killed the Electric Car?"

Success at Last

The hybrid electric Toyota Prius was met with success when introduced in Japan in 1997 and worldwide in 2000. A few years later, in 2006, Tesla Motors Company announced it would start producing a luxury electric sports car that could go more than 200 miles on a single charge. The Chevy Volt (PHEV) and the Nissan Leaf (BEV) were released in the U.S. market in 2010. These market successes, as well as a series of technical advances, at last made the electric vehicle a practical reality.

All of these advances were accompanied by predictions of increased copper usage in automobile components. As these and other automakers began designing, making and selling electric vehicles, it became clear that the tonnage of copper in the automobile industry was set to increase dramatically.

The increasing demand for electric vehicles is significantly affecting the demand for copper.

Specifically, the market for plug-in electric vehicles (PEV) is forecasted to surge, but a significant investment in charging infrastructure is required to support its growth. The Department of Energy began studying this issue and also investing in a nation-wide charging infrastructure, installing more than 18,000 residential, commercial and public chargers across the country, according to the department's website.

According to the International Energy Association (IEA), the total number of electric vehicles in the world grew to two million in 2016 after surpassing one million in 2015. The increasing demand for electric vehicles is significantly affecting the demand for copper. The demand for copper due to electric vehicles is expected to increase by 1,700 kilotons by 2027[2].

Unlike many other materials, copper usage is generally a good investment for the environment. The metal's high conductivity is used to increase the performance and efficiency of a variety of electrical components. Also, copper itself is a sustainable material, because it is 100 percent recyclable.

Through its use in electric vehicles and other renewable energy technology, copper contributes to a cleaner, safer and more energy-efficient environment.

Demand in the USA

According to a report by the Institute for Electric Innovation (IEI), there are currently 567,000 plug-in electric vehicles (PEVs) on the road in the United States[3]. With annual PEV sales in the United States expected to exceed one million vehicles by 2023, it is projected that there will be seven million PEVs on the road by 2025. That's about three percent of the 258 million vehicles (cars and light trucks) expected to be registered in the United States in 2025.

According to the IEI report, about five million charge ports will be required to support these seven million PEVs in 2025. This represents a significant investment in PEV charging infrastructure – and a significant increase in copper usage.

Copper Usage and Battery Capacity

Advances made in portable battery technology have in part been driven by the consumer electronics industry in its quest for longer-lasting power sources for ever-lighter laptops and cell phones. Such battery technology can be readily scaled for use in electric vehicles. These advances allow for full-sized BEVs to be driven on a single charge as far as conventional cars can go on a single tank of gasoline. The batteries can be recharged quickly, they have long life cycles, and they can be manufactured in volume. Importantly, too, costs are dropping.

Large companies such as Tesla and the Chinese company Build Your Dreams (BYD) are committed to the high-volume production of economical batteries for electric vehicles. Until recently, EVs were impractical because of the lack of an inexpensive battery technology and charging infrastructure. These barriers have largely been overcome or are rapidly being overcome.

Tesla makes 100 percent battery-powered electric vehicles (BEVs). Furthermore, the company has also expanded horizontally to manufacture batteries at a massive battery plant called Gigafactory outside of Sparks, Nevada. Production will be ramped up in the next few years. The name "Gigafactory" comes from the factory's planned annual battery production capacity of 35 gigawatt-hours (GWh).

These developments in battery technology led analysts to predict, as mentioned above, that the number of electric vehicles in the United States alone will exceed seven million by 2025.

Global Battery Production

BYD is also a leader in battery technology. It is also the largest electric vehicle, electric bus and battery manufacturer in the world.

BYD now sells in excess of 100,000 plug-in hybrid vehicles (PHEV) and electric vehicles per year. In 2016, for example, according to market research conducted by IDTechEx for the International Copper Association (ICA), BYD sold a total of 114,315 electric vehicles [1]. Furthermore, it should be noted that the manufacture of these vehicles required a total of nearly 26 million pounds of copper!

BYD manufactures 16 gigawatt hour (GWh) of battery capacity per year. The next largest battery manufacturer (Panasonic) has an annual capacity of 8 GWh per year. At least a dozen other battery makers each have a production capacity of 2 GWh or more.

Charging Stations

One of the barriers in the adoption of BEVs is the charging infrastructure. The number of charging stations needs to increase proportionally to the number of BEVs on the road.

According to the IEI Report, the charging infrastructure is fundamental to the growth of battery electric vehicles. The equipment that connects a vehicle to the electric grid is called a "charging station" or "charge port." The report estimates that about five million charge ports will be needed to support the seven million electric vehicles that are expected to be on the road in the U.S. by 2025. These estimates are made in view of earlier studies from the National Renewable Energy Lab (NREL) and Electric Power Research Institute (EPRI).

These charge ports can be roughly classified as three types, including Level 1 (120 Volts), Level 2 (220 volts) and DC Fast Chargers (DCFC). Recharging times range from overnight for Levels 1 and 2; to several hours for Level 2; to less than an hour for DCFC.

This marketplace is evolving and different models are being tested to provide adequate charging ports for PEV owners. The charging infrastructure is typically paid by the entity that hosts the charging stations. These "entities" can be homeowners, commercial property owners, or a public utility, for example. Currently, the charging infrastructure at workplaces and public locations consists predominantly of Level 2 charging stations.

These charging ports typically are rated in terms of kilowatts (kW). For example, BYD charging ports ranging from 3.3 kW to 200 kW contain between two to 17 pounds of copper, respectively.

According to the IEI report, there currently are between 50,000 and 70,000 Level 2 ports in work or public locations in the U.S.; and that number needs to be increased to between 2,230,000 and 2,240,000 by 2025.

A substantial amount of copper is required by BEV chargers. According to IDTechEx's research, BYD's total sale of chargers in 2016 used more than 295,000 pounds of copper.

The Road Ahead

Of course, a battery is not an energy source! Rather it is an energy storage device. Nonetheless, the adoption of EVs, including PHEVs and BEVs, allows for more options with respect to sources of energy. It allows cars to be fueled by alternative, renewable energy sources such as wind, solar, hydroelectric and nuclear energy sources, as well as by fossil fuel sources such as coal, oil and natural gas via power generation by electric utilities.

The thermodynamic efficiencies are comparable for ICE that burns petroleum products and an electric power generator that burns fossil fuels, but the economies of scale make the energy from utilities less costly than the energy from gasoline delivered to the local service station.

The lack of high-density energy storage technology favored the development of the ICE for more than 100 years, but now battery technology and energy costs are tipping the equations in favor of electric vehicles. An efficient and readily available charging infrastructure could be installed economically compared to the cost of gasoline filling stations.

All of these factors are making it possible for the electric vehicle to emerge as the logical choice for most vehicles, including passenger cars, buses and even large commercial vehicles. EVs have the potential of being much more environmentally friendly than their ICE counterparts. A closer look reveals that copper will play an important role in the production of batteries, electric cars and the charging infrastructure.

Indeed, it could be said that the road to sustainable mobility is paved with copper!

References

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2. U.S. Energy Information Association, "Global EV Outlook 2017."
3. Adam Cooper and Kellen Schefter, "IEI Report: Plug-in Electric Vehicle Forecast and Charging Infrastructure Required through 2025," The Edison Foundation, Institute for Electrical Innovation, May 2017.

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