YOUR BASIC GUIDE TO

electric vehicle

TECHNOLOGY AND TRENDS

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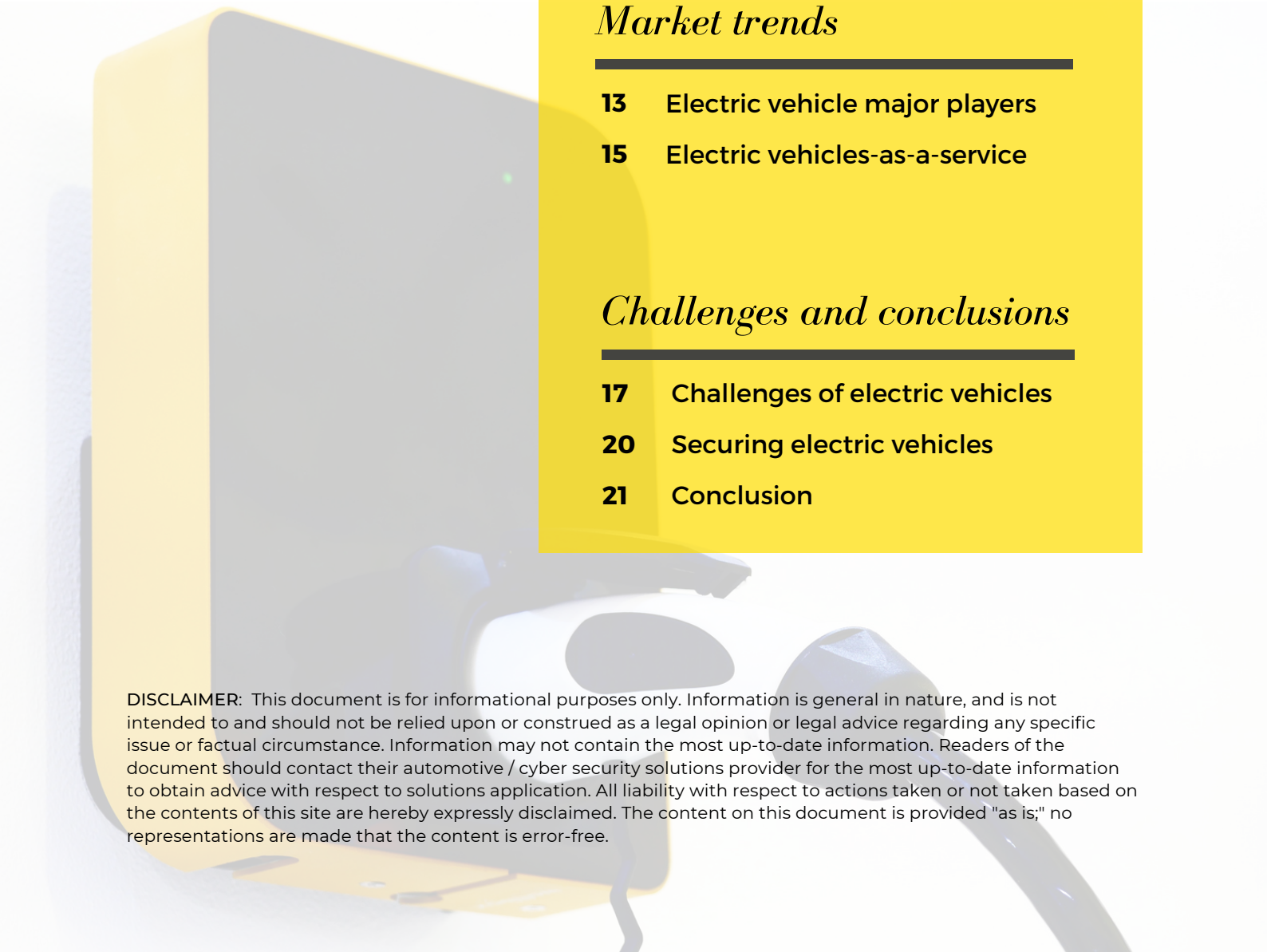


introduction

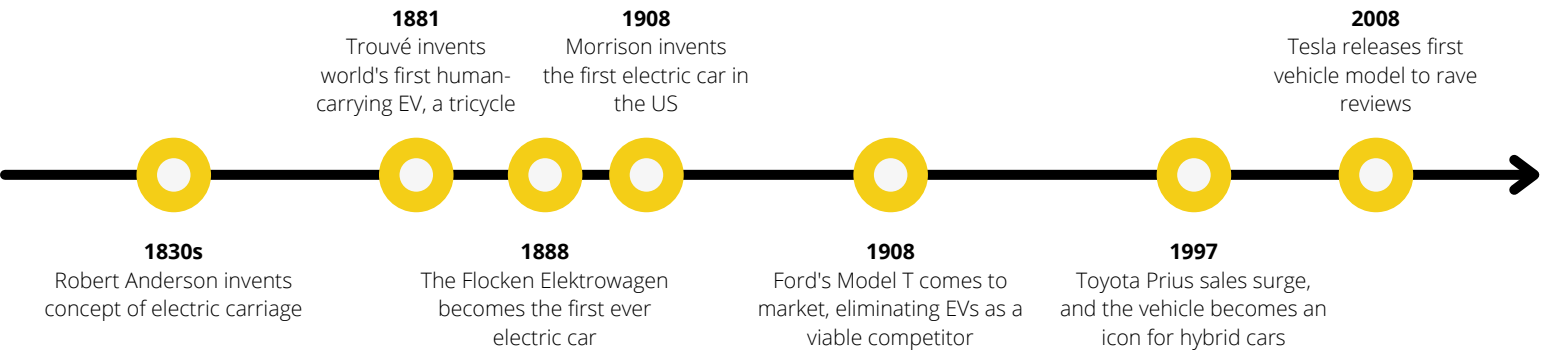
In the present, we do not often react with surprise when it comes to the concept of electric vehicles or charging stations. However, in reality, it has only been a short period of time since the concept of electric vehicles or **EVs** have become accepted in society.

There are many different types of electric vehicles, but whether it's a hybrid, plug-in hybrid, or battery-powered electric vehicle, one thing is clear -- electric vehicles are here to stay.

How much of an impact they will make in society, the environment, and the world depends on what the current EV users and industry experts do with the technology.

This book will cover the basics of the EV world in all areas: history, types, market, and the challenges that lay ahead.

historical background



The Beginning

While it may seem that electric vehicles are a more recent invention, the first appearance of EVs was seen in the 1830s. Scottish inventor Robert Anderson is often credited with coming up with the concept of a crude electric carriage sometime between 1832 and 1839.

This eliminated the need for a horse as the primary force moving along the carriage, and it became the basis of the modern-day vehicle, not just for EVs.

The next century brought on board many other inventors and engineers who built upon Anderson's concept and took it further.

For example, in 1881, French inventor Gustave Trouvé improved upon an existing Siemens electric motor and fitted it to a tricycle, inventing the world's first human-carrying electric vehicle. He ended up adapting this to make it suitable for boating, and tested his prototype on the River Seine, successfully reaching speeds of 3.6 to 9 kilometers per hour (dependent on the direction).

In terms of automotive vehicles, Andreas Flocken is credited with inventing the first electric car with his Flocken Elektrowagen in 1888 in Coburg, Germany. This vehicle was able to reach speeds of 15 kilometers per hour and even sported electric headlights.

William Morrison, an Iowan chemist, was the first in the United States to find success with an electric car, inventing a vehicle in 1890 that moved at 22 kilometers per hour (around 14 miles per hour). His invention sparked interest in the technology in the USA, and many manufacturers began to produce versions of electric cars starting in the late 19th century.

The Downfall

The electric car saw a rise in trends in the early 20th century, so why is it that we are now seeing the "new" technology of the electric car? It came down to timing.

It's important to understand that the technology's rise came at a turning point in automotive history. Most people were still using horse-led carriages, and automotive vehicles were just starting to be considered for personal ownership. Because of this, automotive technology was embraced in many forms: electric, steam, gasoline.

While electric cars brought many benefits to the table like its affordability and quiet engine, these low-cost, quiet vehicles were perfect for socialites who enjoyed getting around the city in a "high-tech" vehicle. However, the early 1900s saw growth in intercity and interstate roads to allow for more long-distance travel, for which electric cars were not a viable option.

The technology also saw a large dip at this time when Ford's famous Model T came to the market in 1908. An extremely affordable automobile coming in at $650*, it was a no-brainer

*Equivalent to around $21,000 in purchasing power in 2021

when it came to buying options, as other vehicles sold for over twice the price. By the 1930s, electric cars were no longer seen on the roads where they had once been so plentiful.

The Resurgence

It took over 30 years for electric vehicles to emerge again, when gas shortages and energy crises in the 1960s and 70s brought about a renewed interest in alternative forms of transportation.

However, timing once again was the enemy, as even though the energy climate called for alternative fuel sources, the electric vehicle-powering technology was still lacking. Many companies attempted designs of battery-powered electric vehicles, but rarely made it to the production floor.

EV speeds made it to about 70 kilometer per hour, and 70 kilometers was the average range before needing a charge. One hours' worth of drive was not worth it for many, especially as commuting times for the general public began to increase with more and more people residing in suburban neighborhoods.

The Push Forward

The 1990s is when we saw another resurgence, but this time, timing seemed to line up more optimally. The 1990s saw a widened level of public awareness in regards to climate change, and many automotive manufacturers like Ford, Chrysler, Honda, Nissan, and Toyota saw a need to cater to this awareness by changing their technology to be more fuel efficient and reducing emissions.

A prime example of the change in industry mindset is represented by the introduction of the Toyota Prius in the late 1990s. The Prius

was an instant best-seller, becoming both a political statement and pop culture icon with the green movement.

This is not to say that electric vehicles were all immediately successful. While the Prius did well as a hybrid electric vehicle, models like GM's EV1, though mass-produced, didn't turn a profit. The first ever mass-produced battery-powered EV was designed in response to a regulation in the state of California which mandated that manufacturers must produce a small percentage of emissions-free vehicles if marketing the product within the state. However, the demand for a vehicle that had a shorter range (around 100 miles, or 160 kilometers) and seating capacity of two was not ideal. GM closed out the program in the early 2000s, as costs for development were far out-weighing any other benefits.

While there were minor setbacks, the 2000s showed that electric vehicles were here to stay. 2006 saw the entrance of Tesla into the automotive industry. The company announced its intention to roll out luxury electric sports cars with longer ranges, and companies began to eye each other as competition.

Since the early 2000s to present day in 2021, we have seen that competition ramp up, as more and more EV models hit the market each year. New battery technology has allowed for lighter vehicles, longer battery efficiency, and cost efficiency as well. In turn, the public's acceptance of an alternative fueled vehicle has also grown. In 2020, global sales of EVs grew 39% to 3.1 million units, even as the total passenger car market (including traditional ICE vehicles) declined by 14% due to the global COVID-19 pandemic.

Legislation for EVs has also seen a rise, with many states declaring plans for eliminating new internal combustion engine-powered vehicles within the next decade or two. Manufacturers have followed suit by also declaring to go all-electric within a certain number of years.

types of electric vehicles

Electric vehicles, or EVs, are now all over the news.

However, the term "electric vehicle" is an umbrella term, and in reality EVs aren't necessary all no-emissions vehicles. EVs can still utilize a traditional combustion engine as well as a battery-powered motor, and can even generate electricity without having to plug into a charge station.

Hybrid Electric Vehicle (HEV)

The Prius is the most famous of this type of EV, which utilizes a traditional internal combustion engine (ICE) with electric propulsion, meaning that the ICE will charge the batteries to power the electric motor.

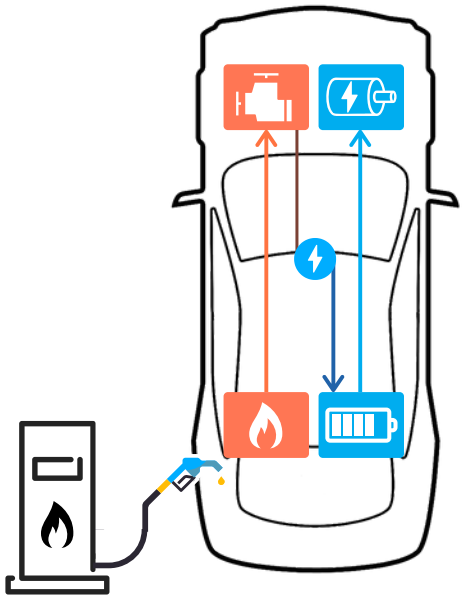


Figure 1.1.
Hybrid Electric Vehicle (HEV)

HEVs still require fuel to operate, though they have a much higher fuel economy and less carbon emissions than traditional ICE vehicles.

The drawbacks of a HEV is its heavier weight due to the sheer number of components involved as well as the price. Because of the number of components, on average HEVs can cost a few thousand dollars more than ICE vehicles. However, this cost can often be offset with governmental subsidies.

Fuel Cell Electric Vehicle (FCEV)

FCEVs use fuel cells to combine hydrogen and oxygen, producing electricity, which then runs the motor. The battery captures braking energy, conserving extra power to smooth out power from the fuel cell.

An interesting distinction of the FCEV is that the only emissions are water vapor and warm air. However the drawback of the FCEV is its higher cost and difficulty in refueling.

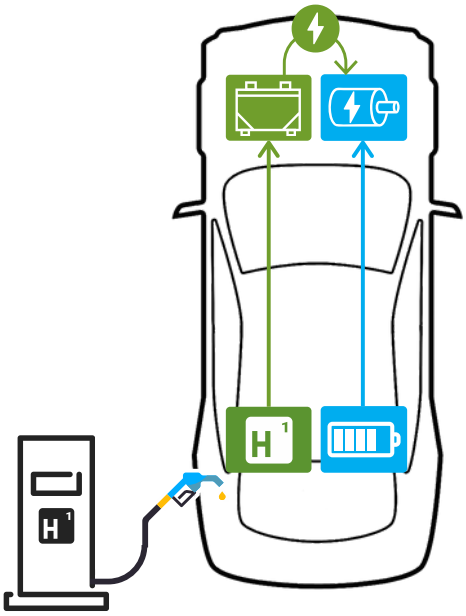


Figure 1.2.
Fuel Cell Electric Vehicle (FCEV)

As of January 2021, there are 45 hydrogen fueling stations, 43 of which are in California. However, with around 8,000 FCEVs in the state alone, many panicked when hydrogen ran low earlier in the year.

Manufacturers are trying hard to make up for this by luring buyers with lucrative discounts and even ,maintenance and fuel fees, so that along with the federal and state incentives for buying FCEVs, drivers can enjoy an extremely low net price. If the hydrogen shortage can be resolved, then this may be an ideal option for drivers in California.

Plug-in Hybrid Electric Vehicle (PHEV)

As its name suggests, PHEVs can be charged for power and runs mostly on the electric motor. However, it still utilizes fuel (like gasoline or diesel) to power the combustion engine, but the engine itself is considered to be backup.

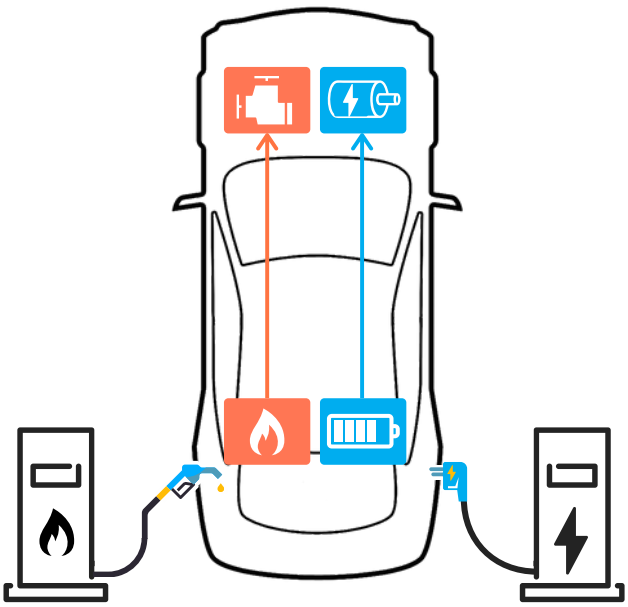


Figure 1.3.
Plug-in Hybrid Electric Vehicle (PHEV)

The downside of the PHEV is that the prices can be higher than other vehicles and because of the number of components involved, like the HEV, can have a heavier weight.

But there are many benefits to a PHEV. Along with less fuel consumption and less carbon emissions, users can enjoy less range anxiety (more on that with the BEV) as there is a backup power source in case the battery charge runs low. The PHEV is a popular option for EV users, and over 40 models are available on the market, mostly in China, followed by the United States and the United Kingdom.

Battery Electric Vehicle (BEV)

When we see EVs on the news, BEVs are what immediately come to mind. BEVs have no internal combustion engine, and are powered solely by electricity. The vehicle plugs into a charge point to recharge the battery.

The vehicle has no emissions and is fairly low-maintenance. However, it is not without its drawbacks.

Charging can take time, and range anxiety can limit driving distance. However, overall popularity is on the rise as they made up over two-thirds of new EV registrations in 2020.

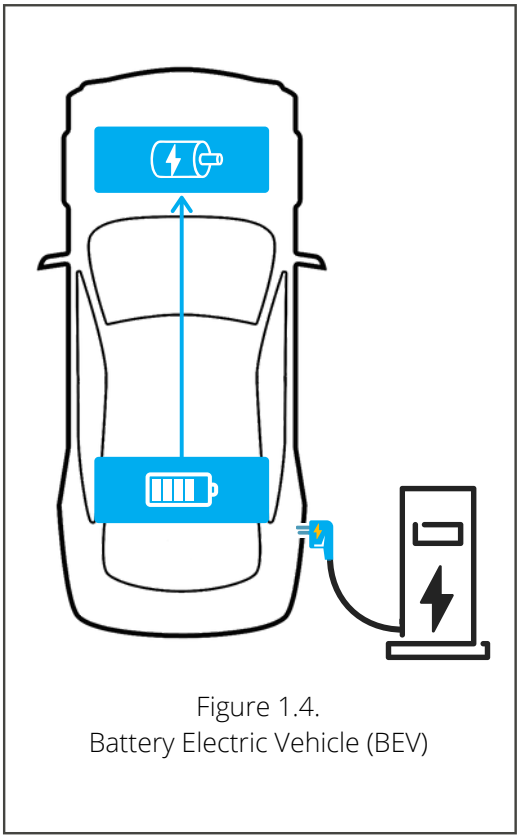


Figure 1.4.
Battery Electric Vehicle (BEV)

electric vehicle charging basics

When it comes to charging Battery Electric Vehicles (BEVs), there's lots of questions that potential users have. We will cover the basics of charging, and how it works.

Types of Chargers

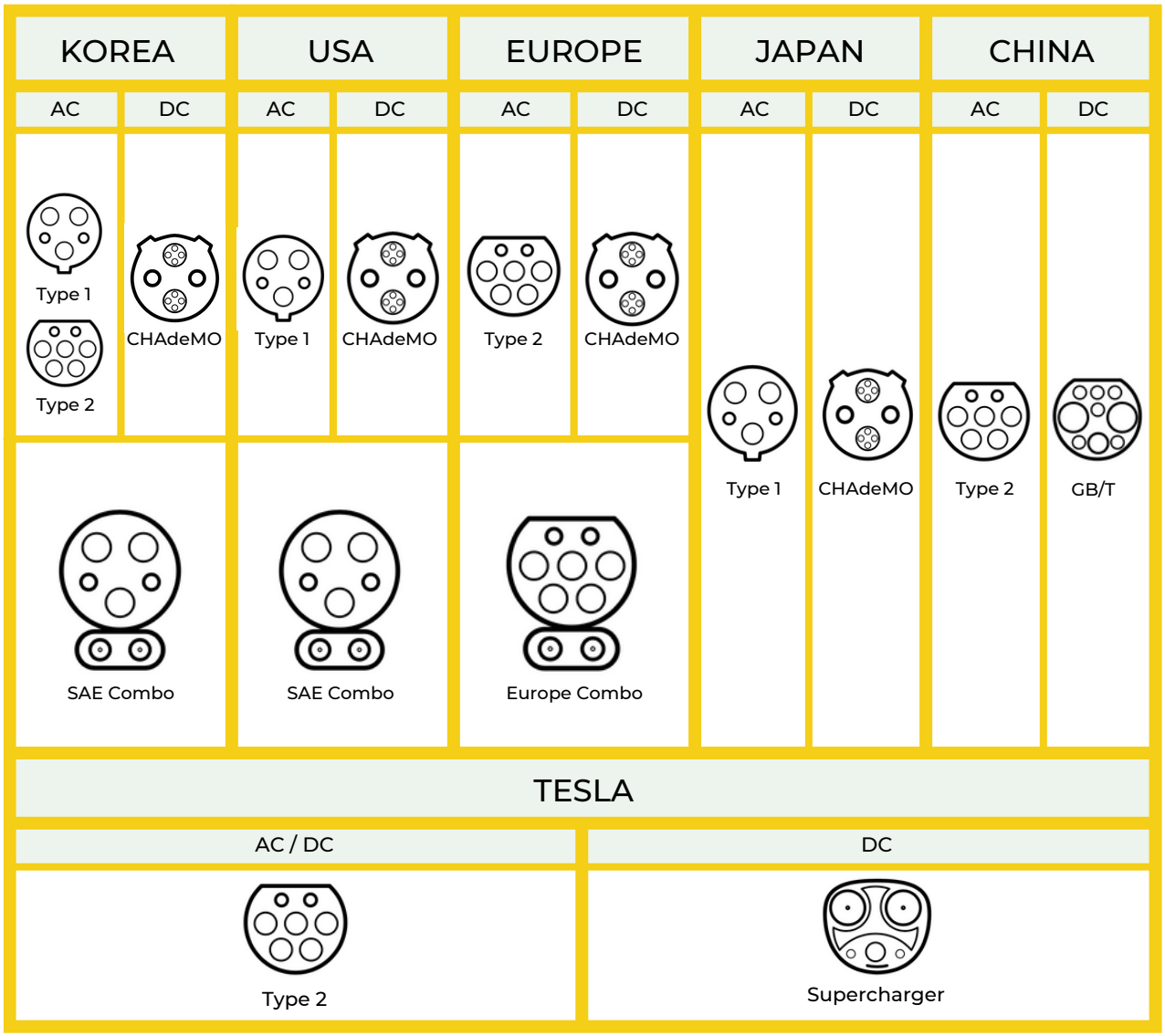
Chargers can be classified by the plug itself, as well as the location of the power conversion. The two types of power conversion are AC and DC charging. AC stands for "Alternating Current" and this is the power that comes from the grid itself. The power eventually needs to be converted from AC to DC ("Direct Current") and for AC chargers this is done within the car in the on-board converter. The DC power then moves to the battery, providing the "fuel" for the EV.

AC chargers have lower required power range (between 16A and 63A), meaning that it's suitable for charging times lasting 20 minutes or longer. AC chargers are the more popular charger, as they have lower production and installation costs, as well as lower charging costs.

For DC chargers, the converter can be found inside the charger, therefore, the car will receive a DC charge without needing to convert inside the vehicle. DC chargers require more power, which means that the chargers installation and production costs are higher. However, charging is much faster, which is preferable for drivers on the go.

In terms of the types of plugs, for electric vehicles the type of plugs required can depend on the manufacturer or the region.

Users can ensure the efficiency in their charging routines by checking the types of chargers available in their area. This may affect the type of vehicle they choose to purchase.



Although the number of chargers is increasingly annually, there are still frustrations from drivers and the industry alike regarding the lack of standardization. Though there are yet to be a universal standard across all countries and manufacturers, countries are doing their part to try to standardize charging methods.

For example, South Korea seems to be going in the direction of standardizing the SAE Combo charge plug.

Charging Time and Range

As mentioned in the previous section, BEVs have different chargers depending on the manufacturer and region. Similarly, the time that it takes to get a full charge can also depend on the vehicle, but also the charger or charging method being used.

For example, to charge a stand BEV model with a 63kWh battery using a residential charger (240V) (depending on the kW) anywhere up to 15 hours to get the battery to 80%. However, with commercial chargers which often have a higher kilowattage, the same charge can be obtained in under an hour.

However, this can seem daunting for ICE vehicle users who are accustomed to spending a maximum of a few minutes waiting for their gas tanks to be filled. Thankfully, there is a comparable method for EV users: DC fast chargers can charge at 150-400kW which means an 80% charge can be achieved in 8-20 minutes.

Drivers who go long distances in their vehicles tend to charge their vehicles two to three times a week. Most EV users, however, prefer to use the "top-up" method, where users will park in spaces with charging infrastructure readily available. As they are going about their day, their car can charge as much as possible within the time frame available.

This wards off potential range anxiety.

"Range anxiety"

Range anxiety refers to the feelings many EV users experience when they fear that their vehicle will not have sufficient charge to reach its destination, stranding the vehicle and its driver/passengers. This is particularly prevalent to BEV users as charge points can be few and far between in many regions.

With the growing trend of BEVs, however, manufacturers and charge point operators have sought to increase the availability of charging infrastructure, develop more convenient battery-swapping technology, and extend the range in newer models of BEVs.

It is difficult to pinpoint the exact distance a BEV can go on a full charge as batteries and chargers differ by manufacturer and by region. However, depending on the vehicle model, these days EVs can go anywhere from 200 kilometers to 500 kilometers on a full charge. The Tesla Model 3 LR, for example, can make it 560 kilometers before needing to recharge. This distance is expected to increase as research and development of EV batteries advances.

Charging Costs

A benefit that many EV users tout is the financial savings associated with owning an EV. Though the vehicle itself can cost a bit more than a traditional ICE vehicle, the general consensus is that electric vehicles are more affordable in the long run due to their charging costs.

According to the U.S. Department of Energy, assuming that electricity costs $0.13 per kilowatt-hour (the national average), charging an EV with a fully-depleted 66 kWh battery will cost about $9 to reach 100% charge.* In the UK, the average domestic electricity rate is £0.14, about $0.20, and in the European Union, the average rate is €0.21, or about $0.26, so costs can vary.

Additionally, due to government support and subsidies, along with the lower cost of charging vs. filling up on gasoline, EVs can be a more economically efficient option when purchasing a vehicle in the long run.

*U.S. Department of Energy, Alternative Fuels Data Center

electric vehicle major players

Traditional ICE vehicle manufacturers as well as new start-ups are hopping on board the electric vehicle train. With new models released each year, one thing is clear: EVs are not going anywhere. Here are some of the biggest players in the EV game.

Hyundai

South Korean manufacturer Hyundai has been in the EV game since the 1990s. Its 2016 release of the Ioniq to rival the Toyota Prius was a major success, even launching as its own new electric brand beginning in 2020. The company began developing smaller crossovers in the mid-2010s, with the Kona (available as HEV and BEV) releasing in 2017. The Kona has been a top selling EV model since its release. It announced in mid-2021 that it planned to invest US$7.4 billion in EV production, production facility, and smart mobility.

Volkswagen

The German motor vehicle manufacturer was founded in 1937. Historically famous for its iconic Beetle and VW Bus, the company's turned to the emerging EV market with electric ID line of vehicles. Volkswagen says it anticipates up to 22 million vehicle sales by the end of the decade, and it will be interesting to see how the manufacturer meets its goals with its new operations strategy.

Kia

Founded in 1944, Kia is the second largest automotive OEM in South Korea. Minority owned by Hyundai, the two companies hold the 4th largest share in the global EV market (as of March 2020).* Kia has promised to invest over 10 trillion won (US$8.98 billion) in future mobility and the company aims to fulfill 11 EV models by 2026, with sales to 1.6 million units by 2030. The company seems well on its way, with surges in sales of the Kia Niro and XCeed PHEV.

Tesla

A relatively new player into the game, Tesla has only been in the industry for 15 years, but time was not a factor: this electric / connected vehicle manufacturer was the 2019 market share leader and reported in 2020 that it could reach 20 million vehicles by 2030. Its electric vehicles have become some of this generation's favorites, with its performance capabilities and technological details. What it lacks in automotive legacy, it's making up for in quick worldwide expansion. The company will be building new factories in Texas and Germany, opening by 2022.

BYD

"Build Your Dreams" Auto is a Chinese automaker based in Xi'an, China. The company is backed by US billionaire Warren Buffet, and it recently announced that it has shipped off its first batch of vehicles to Norway. Chinese automakers and startups are strategically marketing to the European Union, where EV adoption has gone at a faster pace. In Norway, EVs have dominated new passenger car sales since 2018.

*Pulse News, 2020.

electric vehicles as-a-service (MaaS)

McKinsey reported in mid 2020 that EV sales rose 65% from 2017 to 2018, but grew only 9% the following year in 2019. EV sales then declined 25% in the first quarter of 2020.* Though some of this can be attributed to the global COVID-19 pandemic, there is no doubt that overall, vehicle ownership growth is starting to wane.

This points to a growing trend among the current generation of drivers and passengers to utilize mobility services and subscriptions rather than purchase a personal vehicle. The concept of MaaS is not a new one, but as transportation trends move outside of the traditional ICE vehicle, more and more companies have begun to research how mobility services can be electrified.

The move to electric MaaS business models also stems from policy. More states, regions, and even countries are mandating the ban of ICE vehicles, putting pressure on manufacturers to produce more zero emissions vehicles and services to evolve with new regulations.

A major selling point of the MaaS business model is that the entire service is run from a unified platform, allowing for a seamless management platform for the service operator, and a convenient user interface and payment platform for the consumer.

Many of these mobility service platforms are managed by a

"Mobility-as-a-Service"

Mobility-as-a-Service or "MaaS" refers to the use of a joint digital channel that enables users to plan for, use, and pay for mobility services all on a unified platform. It is an umbrella term that can cover a number of services, both public and private, which seek to meet user needs for transportation.

*McKinsey, 2020

Fleet Management Systems or a FMS.

While for the average passenger, getting a ride through a mobility service may seem like a simple action, in reality, multiple players and data exchanges are underway. When you add security measures and payment/charges to the mix, for a seamless service experience, a unified system is necessary.

This is where the FMS comes in. The FMS can collect vehicle data, analyze said data, and then deliver the diagnostics to the service operator so that they are able to more efficiently run their business operations. It can handle the payment options, ensure also that certificates from all entities are verified, and that all functions are optimized.

Fleet management solution demand has grown significantly in the past few years precisely because of the expansion of the mobility ecosystem. Cars will continue to evolve using alternative fuels, even becoming increasingly autonomous - and Mobility-as-a-Service is sure to follow along.

challenges of electric vehicles

While the current trends of EVs are heading in a positive direction, this is not to say that EVs are without their challenges. Here are three of the biggest issues within the EV landscape.

Range Anxiety

Mentioned earlier, range anxiety is a term that describes the feeling EV users experience when they fear that they may not have sufficient charge to be able to make it to their destination or to the next charging point.

This is a major hurdle that vehicle manufacturers have been aware of, and are working to remedy. By developing battery technology and efficient engine operations, range will certainly increase as time goes on. It will be up to the automotive industry to reassure potential drivers of the increasing ranges so that they will be more willing to transition from what they know to something new.

Charger challenges

When it comes to the issues that EV drivers share, many have to do with the charger itself of the charging process. Let's take a look at this more closely.

Charging Times and Pricing. Because electric vehicles get their energy from the grid, charging prices depend on the time of day. For example, the afternoon and early evening are considered peak hours, meaning it is not an optimal time to charge a large vehicle.

This can be minimized by charging during non-peak hours, but this requires much more intentionality than simply filling up one's gas tank when close to empty.

To remedy this issue, many automotive experts are looking towards V2G or Vehicle-to-Grid technology, where the vehicle would not be simply receiving charge from the grid, but giving back to it as well. This type of bidirectional charging system allows for benefits on both sides: the vehicle would sell back some of its energy during peak hours and pay for charge at low-peak times.

While the technology has not hit the market yet in a major way, many manufacturers have had their eyes on making their vehicles more compatible with bidirectional charging, and it could be a game-changer.

Charger Types. For those of us that still drive the traditional ICE vehicle, we probably don't give much thought to where we get our fuel. Pricing may contribute to our decision-making, but every gas station will essentially sell the same fuel, and all the gas pumps will fit any ICE vehicle.

However, with EVs, that's not necessarily the case. As outlined earlier, the type of fast DC charger depends on the manufacturer, which means that although there may be a charge point nearby, the charger might not be compatible with your vehicle.

To remedy this challenge will take time, as the distinct ports will require larger infrastructure change. However, as time goes on, experts say that it's possible that CCS and CHAdeMO will converge, likely into the current CCS standard, which is backed by the European Union.* It is not certain if this will be true for Tesla, the only manufacturer with its proprietary charger. However, Tesla does

*Pasquale Romano, ChargePoint, 2018.

offer adapters for both the CCS and CHAdeMO plugs.

However, the issue with chargers is only a small portion that faces the consumer of the larger conversation surrounding the challenges of interoperability and standardization within the electric vehicle industry. There are larger issues when it comes to the interoperability between systems management - the communication that occurs between the vehicle and the charger, the charger and the charging network, and the software that manages all the data from the vehicles, chargers, and the charging services.

Infrastructure interoperability challenges can be inconvenient on the part of the driver, the vehicle manufacturer, as well as the charge point operators and service operators (often called mobility operators), and this is why many are looking to Plug&Charge (or PnC) as the next standard of vehicle to grid communications.

In 2014, the ISO 15118 standard was developed with the goal of making the charging process more convenient for drivers. The standard manages the PnC technology, allowing the driver to be able to plug in and charge their vehicle without using a mobile application or an RFID card, making the entire process very seamless. Following the ISO 15118 standard and also related protocols like the Open Charge Point Protocol, users and service providers would be able to enjoy both front-end and backend interoperability. Especially for drivers in the EU or the US who have to cross country or state lines, this can be a major drawing point for wider EV adoption as drivers are no longer limited to a single charging network.

But is it secure? Let's look at this in the next section.

*Pasquale Romano, ChargePoint, 2018.

securing electric vehicles

The term "electric vehicle" brings about the image of chargers and plugging in. However, it's about much more than just the charger itself. When charging an EV, information is exchanged between the vehicle, the charge station, and the charge station / mobility operators. This information includes sensitive data like credit card or payment information, Personal Identifiable Information (PII) and other car data.

As we mentioned in the previous section, protocols like the OCPP allow for users to enjoy front-end and back-end interoperability. The OCPP also integrates security features into the specifications of the standard.

However, because the charging process isn't just about the charging station, having a security system that covers the entire charging process is essential. Ideally, the security solution should be in compliance with the aforementioned ISO 15118 standards and verify identities of both the vehicle and the charge point. Supporting OCPP is a must, ensuring that the contract between the charging station's management systems and also the mobility operators is verified, and safely delivers to the vehicle.

This allows for a truly secure Plug&Charge process for all stakeholders. By verifying identities all across the board, all entities can enjoy safe exchange of information and data.

conclusion

When Anderson conceptualized the electric vehicle in the 1830s, perhaps he was simply trying to come up with an efficient transportation method. However, now in the 21st century, the EV has become much more than mere transportation. A rolling connected, fuel-efficient, emissions-free device, an EV is also a moving, navigating Internet device. Essentially, the EV is a supercomputer on wheels. As autonomous technology continues to develop, EVs will only become more efficient and widespread.

EVs will also become smarter due to the sheer amount of data going through its internal systems. Securing this data and information will be one of the biggest hurdles the industry will face in the coming years.

Regulations for stricter standards and approval processes for cybersecurity management in vehicles is already underway, and it may just be a matter of time before it begins to apply to charge points as well as mobility operators.

For more information about AUTOCRYPT and its V2G / PnC security solutions, visit www.autocrypt.io