# The Biggest Problem Facing Electric Vehicles

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***Abstract*: In this discussion we narrow down the obstacles facing electric vehicles to the most critical factor, the charging time. We will use the terminology of the tipping point, that is, a crucial point or volume or number or threshold according to which a technology or a product is aimed towards a certain path towards market dominance. While factors such as range and price are quickly approaching the tipping point, the charging time of electric vehicles remains very slow and very few vehicles even come close to the tipping point. We will also try to suggest some methods that can help reduce the time thus getting much closer to the tipping point. We also compare some popular and common electric vehicles from a wide variety of companies against the background of many different parameters.**

***Index Terms*: Electric Vehicles, Range, Lithium Ion, Watt**

## I. INTRODUCTION

All with any disruptive technology there is a tipping point, a point at which the technology will almost certainly dominate the market or its specific application [29]. The tipping point for smartphones, i.e., when the growth rate of the smartphone market was substantial, and greater than that of their predecessor for example, the growth rate of smartphones versus feature phones was 40% versus -5% in the first quarter (Q1) of 2018 -a clear indication of the dominance of smartphones [2] [1]. The same applies to electric vehicles, which, as the market forecasts for electric vehicle sales show, are almost on a certain path to dominance and will eventually gain a large market share in the automotive sector. Over time, electric vehicles will replace their predecessor, the internal combustion engine. However, the chances are that when asked about the next car, it will undoubtedly be a non-electric one. As surveys show, of 63% of those interested in electric cars, only 31% would be willing to buy them, which shows that the technology is certainly not at the tipping point yet [4].

According to a survey, price ,range and charging time are the top three main challenges for mainstream electric vehicle adoption [5].For consumers, in a survey, purchase price is a very important consideration when buying a new car, suggesting that a high price can put many customers off when it comes to electric vehicles. Although electric vehicles cannot currently compete with conventional vehicles in this regard, they are very close .Moreover, a lot of people do not realize how high entry prices are offset by lower maintenance costs. [5] A look at the price of the 3 best-selling Tesla Model 3 electric vehicles of $ 37,990 [6], the Chevy Volt $ 32,496 [8] and the Nissan Leaf $ 32,545 [7]. This shows that the purchase price of electric vehicles is not the factor holding back the widespread use of electric vehicles. In addition, many countries also provide substantial subsidies for electric vehicles, bringing the price very close to the tippingpoint of $ 36,000 [5].

The survey also says that the ideal range for an option to buy a car should be 291 miles or 469 kilometers, roughly the distance between London and Paris [5]. Experts also relate these two factors, in fact, the battery is the most expensive part of electric vehicles and increasing the range will significantly increase the price of the car, so this is a compromise. However, advances in this area are helping to lower the cost of the battery as well as increasing the cost. In 2013, the average price per kWh for an EV battery was over $ 650, meaning the base Tesla Model 3's 50 kWh battery with 220 mile range would cost $ 22,500 - 2 / 3 of what's for sale. Today the average price per kWh is US $ 137, which means that the same battery pack would cost around US $ 7,000 .Also the price per kWh is expected to drop to just US $ 100 by 2023 [30] [17].

Electric vehicles may not be here yet, but they are very close, and will be in the years to come in terms of the price of the battery and the total cost of it, so it's clear that range and price aren't very important factors preventing the average consumer from buying an electric vehicle [17] [15]. The burden however is charging. While much emphasis is placed on other factors, the development in the area of fast charging or DC charging is much slower and is detrimental to the acceptance of these vehicles in the mass market.

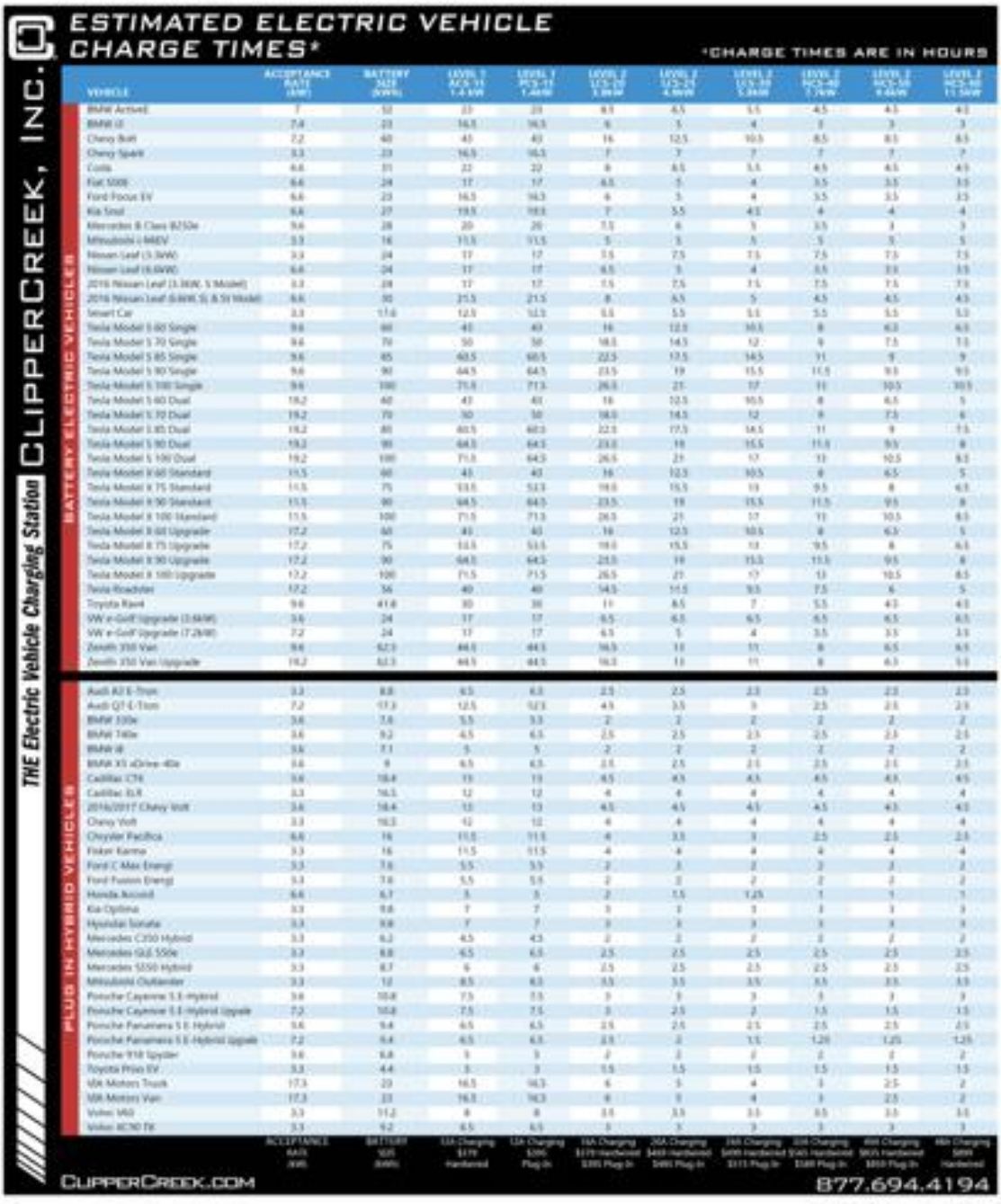
## II. THE CHARGING PROBLEMS

Wherever Charging time is precious. Consumers in a survey rank charging time as the most critical challenge that will drive the adoption of electric vehicles, but how quickly electric vehicles need to be charged before consumers switch to electricity? - 31 minutes is the magic number.Thus the 31 minute charging point is considered as the tipping point. More than half of the consumers surveyed said they would consider purchasing an electric vehicle that could be fully charged at or before the tipping point [5]. A 31-minute charge time will mean a significant increase in electric sales, with electric vehicles accounting for $ 224 billion per year in all eight markets in our study by 2025, when this tipping point is reached. Globally, this suggests that electric vehicles could account for 10% of all new cars sold by 2025. Research also shows that consumers want an electric vehicle that charges in 31 minutes or less, and so this is considered a tipping point for mass adoption.[5].According to Castrol ,

*"The length of time it takes to charge a battery was the most important critical challenge for consumers. According to our study, the mean charge time tipping point for mainstream adoption is 31 minutes, equivalent to the length of the average lunch break. Although this is far longer than the average internal combustion engine (ICE) refuel, it is only 10 minutes longer than our respondents' average break at a rest stop (21 minutes)."*

The same survey also suggests that the charging time tolerance, i.e. the average waiting time consumers spend at a charging station, is also associated with a good charging infrastructure and that consumer expectations also depend on location and average waiting time. While ICE automobiles take less than 5 minutes to refuel , consumers of Electric Vehicles say they can wait an average of 31 minutes at a charging stop to recharge their battery to 100%. With the right infrastructure and equipment at filling stations where consumers interrupt their journeys, this additional waiting time has the potential to promote a dynamic new "charging economy" [5].

Fast charging is critical to consumer confidence, but research has shown it to be a lower priority for businesses [2]. The reality is that few vehicles come close to this point and those that can only do so because of the ultra-fast charger that is not available to everyone and in every city. Charging an electric car at an electric charging station takes between 30 minutes and a few hours and they differ in performance and their power output.Moreover , if there are fluctuations in the voltage , it can potentially damage the battery. The case for home chargers is long; the charging process can take 10-20 hours under ideal conditions [12] [27]. The graph shows the charging time of some of the most popular electric vehicles [18]:




Only Tesla Model 3 comes remotely close to this target and charges 83% in 31 minutes that too only when charged with the state of art Tesla Supercharger . On 83% charge , the Tesla Model 3 can cover a distance of only 196 miles of range and that too in ideal conditions . Colder conditions require longer charging times .This proves that one of major factors stopping the widespread use of EVs is the charging[30] .

**Technical Reasons:**

1. The rapid charging of electric vehicles can cause lithium plating problems. This problem occurs when the temperature of lithium ions deposited around the battery anode during the charging process is very low; reducing battery life and safety. Improving fast charging at low temperatures usually sacrifices battery life.

2. Lithium-ion batteries use electrochemical processes, whether they are charging or discharging, and these chemical reactions depend on temperature. If there are changes in factors such as temperature and humidity the battery can expand, pressure can build up inside the battery, and eventually the battery will burst or explode. With fast charging under wrong or non-ideal conditions, all of this can become a reality, and thus thermal management becomes even more important to prevent such disasters[19].

## III. Methods of Fast Charging

The AC current needs to be converted into DC for the sake of charging batteries as it is not possible to charge a battery with AC and that is why we need a AC to DC converter (or inverter).The AC in most houses are for the purpose of usage by day to day devices and not by electric cars with comparatively ginormous batteries .For example ,to be able to take a Tesla Model 3 from almost empty to almost full in thirty minutes , a 120kW to 250kW charger is required. A charger of that kind is very expensive and costs more than $57,200[26][19] and is about the size of a very large fridge. It's not exactly practical to have this as an internal component of the car.Companies get around this method in various ways:

**The DC Fast Charging:**

AC charging is the type of power found in most types of electrical energy - AC outlets can be found in most places, and almost electric vehicle chargers can be found in homes, shopping malls, and offices and corporate locations, AC chargers, especially Level 2 An AC charger supplies power to the inverter in the vehicle and converts this AC power to DC power to charge the battery. The speed of the on-board charger varies from company to company but is limited due to being very heavy and expensive. This means that depending on different companies , different inverters and different intake capacities ,it can take between four and five hours to more than a day to achieve a 100% charge at level 2 [20]. DC Fast Charging avoids all the limitations of using an inverter to convert AC to DC, DC direct to battery.Charging speed depends on battery size and power, and many other factors, but many vehicles can handle most DC -Fast chargers can be charged to 80% in less than 60 minutes which provide greater range and faster charging. The quick charging method allows most consumers to charge their batteries in under an hour for a day, which is much closer to the 31 minute mark and a huge improvement over overnight or long hours charging.

Older vehicles had limitations that only allowed them to charge in 50 kW DC units, but newer vehicles are now coming on the market that can draw nearly 270 kW as the size of the battery has grown significantly since the beginning of the 20th century.DC chargers have achieved ever higher outputs to meet the maximum energy consumption of electric vehicles and can now reach more than 300 kWh.

All major manufacturers of DC chargers offer multi-standard devices that offer the option of charging via CCS or CHAdeMO, as the Tesla Supercharger can only service Tesla vehicles, but Tesla vehicles are capable of other chargers, in particular CHAdeMO, to be used for fast DC charging via an adapter.

**Two Battery Implementation:**

With this charging method, the battery of an electric vehicle is divided into 2 parts and each part works independently, i.e. it is charged separately and using several sockets. Charging points for separate batteries can be provided separately or all at one collection point. The logic is that a much faster charge time is possible with two batteries. For example, consider a Car X with a 100 kWh battery and a Car Y with Y with 2 50 kWh batteries. Also keep in mind that Car X will take a total of 10 hours or 600 minutes to fully charge. We also know that batteries take much longer from 50% to 100% than from 0% to 50%. With these facts, we can theoretically say that if Car Y has similar performance to Car X, the two separate batteries will take about 5 hours to fully charge. However, due to the polarization of the cells, it will likely take around 7 hours, 30% less than the traditional form of the X-car, plus it can break the battery into a much smaller fragment and use the logic similar to a faster charging mode.[23][24][25]

## IV. Conclusion

While the advances in the field of Electric Vehicles are being made some aspects of the charging time are still need to be worked on .Although charging time is not the dealbreaker in many situation , the sheer time of charging repulses some buyers from choosing electric vehicle and solving this issues or coming close to the 31 minute mark will be very beneficial for the industry and also will make way for the mass adoption of electric vehicles - $225 billion market by 2025[5] .The methods suggested in the discussion are already being used by some companies and manufacturers but only in certain places and in limited capacities .The writer believes the bringing down the cost of supercharger and building infrastructure that supports it will most definitely increase the sales and thereby lead us towards a greener future.Bringing charge times down to 31 minutes for all consumers is the first part of this critical challenge for the industry, but the goal is charging as quickly as an ICE refuel.

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