

Electric vehicle charging station components and current scenario

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ABSTRACT

Since the range of an electric vehicle (EV) is important, vehicles with the longest range are preferred. As a result, a survey is conducted on the longest-range vehicles commercially available to estimate the charging power required. EV range has recently increased significantly and can now be charged at home, adding to the benefits of EV. The paper will present the best three EV models with the longest range. So, the specifications of the most popular EV commercially available had been analyzed. Nonetheless, charging stations are still required, which is a critical issue. This paper discusses various approaches to EV charging stations that rely primarily on AC or DC power supply. The previous year's accomplishments will be highlighted. The three EV charging station levels will be thoroughly addressed. It is primarily classified based on voltage, power and types. In this type of charging EV must equipped with rectifier to change AC-DC to charge batteries. The impact of rapid advancements in power electronics technology has been discussed as AC-DC converter, as its advancement will determine the future of EV charging stations. Renewable energy sources (hydropower, photovoltaic, and wind) are now essential as energy source. Recommendations for increasing EV sales will be made.

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1. INTRODUCTION

Fossil fuel resources are running out, and internal combustion engines (ICE) are a major source of pollution and global warming, their use must be drastically reduced. When used as a source of transportation, electricity has several advantages, including high efficiency and no emissions [1]. Since the late 1800s, ICE has been used as a prime mover for vehicles powered by fossil fuel. Then, instead of ICE, switch to electrification and use electric motors. [2], [3]. The following modifications occurred: ICE to electric vehicle or EV, then dual fuel vehicles, and finally plug-in hybrid electric vehicles [4], [5].

Transportation, as a source of emissions, has increased by 74% over the last twenty years globally. It is critical to begin raising awareness about climate change in order to control emissions. The goal of the entire world is now to reduce emissions in all sectors in order to avoid the greenhouse effect. At the global level, ICE vehicles accounted for 16.2% of total emissions [6]. All types of EV, including light-weight, battery-powered EVs and heavy-duty commercial vehicles, account for only 2.5% of total sales [7], [8].

Transportation includes not only ground travel but also air and sea travel. In the case of ships, electric power is obtained through a generator unit that runs on fossil fuel. To reduce emissions, the goal is to replace all three modes of transportation with electric motors. By 2035, the aviation industry will be 25% electric or hybrid [9], [10]. Human health can be improved by increasing the use of EVs, which reduce air pollution, particularly in

urban areas. Since transportation accounts for 24% of CO₂ emissions, while ground transportation accounts for three-quarters of these emissions, using an EV significantly reduces CO₂ emissions [11], [12].

Every year, approximately 3.7 million people die as a result of air pollution-related causes. The main source of it is vehicle emissions of all types. As a result, the use of EV could save many lives each year [13], [14]. Several years ago, 0.9% of EVs were on the road in the United States, while 1.4% in the United Kingdom, making emission reductions not sensible [15]-[17]. EV sales have been slow in past years due to factors such as vehicle cost, battery charging time, and driving range [18], [19].

On the other hand, EV manufacturers are able to solve the majority of these issues. According to the International Energy Agency (IEA), 40 to 70 million EVs will be sold globally by 2025, up from only 2 million EVs a few years ago [20]-[22]. It is widely acknowledged that EVs are at the forefront of transportation electrification, [23], [24]. Within a year, Tesla introduced 25,000 EV in the United States [25]. To get there, the following steps must be taken: i) The cost of an EV must be less than or equal to the cost of an ICE vehicle; ii) EV range must be greater than or equal to that of ICE vehicles; iii) Charging stations should use renewable energy to obtain green energy in addition to low-cost and fast charging stations; and iv) The government should fund public charging stations, which are an expensive piece of infrastructure.

2. ELECTRICAL VEHICLES LONGEST RANGE

The longest distance covered with one charge is the most important factor considered when aiming to own an EV, as shown in Figure 1. EV range has recently increased significantly and can now be charged at home, adding to the benefits of EV. The following section will present the best three EV models with the longest range. So, the specifications of the most popular EV commercially available had been analyzed [26].



Figure 1. Electrical vehicles with the longest range

2.1. Mercedes EQS

It has a range of approximately 730 km before needing to be recharged. The battery has a capacity of 108 KWh and can be charged from 200KW to 80% capacity in half an hour. While recharging at home from a 7 KWh source takes 15 hours.

2.2. Tesla model S dual motor

This model has a range of 650 km and is considered the best in the United States. It has a 100 KWh battery and can charge up to 80% capacity in 40 minutes using the Tesla supercharger grid. At home, it takes 14 hours to recharge.

2.3. BMW i7

While the BMW German type EV has a range of 620 km. However, this type has the advantage of charging up to 195 KW to 80% capacity in 30 minutes. While Chinese automaker Geely announced at Jan 28, 2023 that with a claimed 1000 km range on a single charge. According to the previous survey, even EVs with the

longest range (600-700 km) require charging after several trips, depending on usage. As a result, charging stations must be installed throughout various countries, including cities and roads.

3. ELECTRIC VEHICLE CHARGING LEVELS

Unfortunately, there is currently a scarcity of charging stations, particularly long-distance charging stations. These fast-charging stations have a power output of more than 22 KW. While charging stations up to 22 KW are known as local charging or slow charging [27], which is appropriate for EVs when parked for an extended period of time, such as in an office parking lot or at home. Maximum power means charging an EV for a short period of time when the charging rate slows and the battery is at a low state of charge. There are currently 110,000 fast chargers installed worldwide, with 210,000 public slow chargers in use, as show in Figures 2 and 3 [28]. Tesla's most recent models, the S and X, can be charged at up to 120 KW, which is considered the fastest charging [29]. Recently, the majority of fast chargers in the world have been up to 50 KW, but several projects under construction have reached 350 KW, which is above the capability of EV exits [30]. Another definition is converting stored energy into movement, which is how charging powers can be converted to a kilometer per minute rate. The EV model is important in this regard; for example, the Tesla Model X SUV achieves 5.5 km/KWh [31].

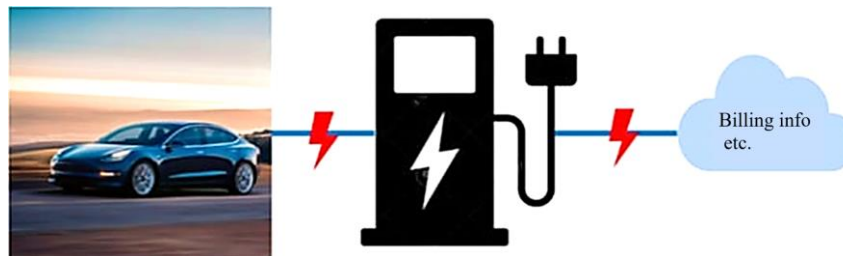


Figure 2. Interception of information via charging stations [32]



Figure 3. EV charging station

3.1. Voltage

If EV at home the voltage available is 120 volts AC and some other countries 220 volts AC, which known as levels 1 and 2 and it is slow charging. In this type of charging EV must equipped with rectifier to change AC to DC to charge EV batteries. While fast charging is needed 480 volts DC required which aviable at charging station which known as level 3 fast charging.

3.2. Power

As shown in Figure 4 and Table 1, there are three charging levels for EVs based on power and speed. Level 1 is the slowest, followed by the faster levels. Levels 1 and 2 are the most widely used charging levels, and can be found in a variety of locations such as home and office parking lots. These levels cover daily EV use but

not long-distance travel. EV owners must consider unexpected journeys or charging station malfunctions. As a result, it is recommended to charge an EV for a multi-day trip.

The common factor among all three levels is that charging time is determined by the size of the battery. Each EV travels approximately 4500 km/ year or 12 km/day on average. So, it consumes 355 KWh per month and 4310 KWh/year. There is no hard and fast rule for this because habits differ from country to country, as does the age of the EV owner. Based on that, an EV charged at home consumes 2.5 KWh/day, 75 KWh/month, and 900 KWh/year, assuming an EV consumes 0.2 KWh/km on average [33].

Table 1. EV charging levels (for one point only)

EV charger type	Specifications
Level 1	AC slow charging with a capacity not exceeding 7.2 Kw
Level 2	AC fast charging with a capacity more than 7.2-22 Kw
Level 3	DC fast charging with a capacity more than 22 Kw

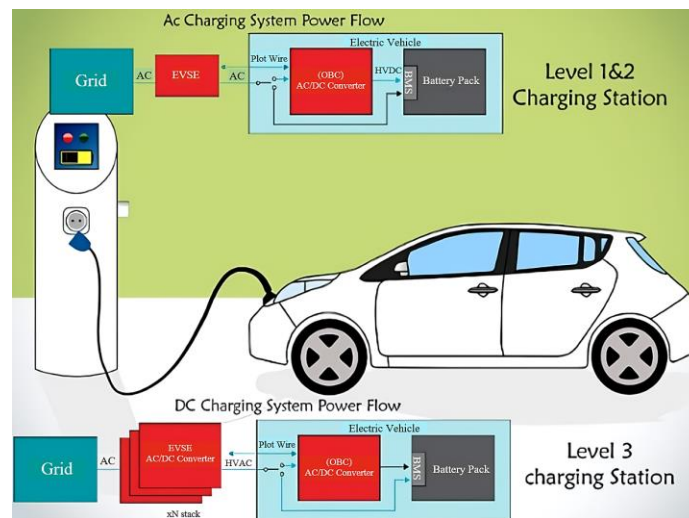


Figure 4. EV charging levels

3.3. Types

The main issue with EVs is that the driver is accustomed to visiting a fuel station and, within 5 minutes, the ICE vehicle is refilled with fuel and can run for approximately 400 kilometers. EV batteries, on the other hand, require more time to recharge. The ultimate goal of an EV charging station is that charging an EV takes the same amount of time as charging an ICE vehicle with fuel. To get to that point, a higher transformer at medium voltage is required, resulting in a more complicated system with higher labor, size, and installation costs. The primary charging techniques for fast charging stations are AC/DC or DC/DC.

4. AC TO DC CONVERTER

Most charging stations use it because the most common supply AC and conversion to DC are tested and reliable Figure 5. Tesla used the AC grid in 2021 to build an AC/DC station network with 23277 superchargers, with an average of nine units per station worldwide [34]. North America has 1100 stations, Europe has 600, and Asia has 500 [35]. There are many established patterns and experimentally tested rectifiers suitable for AC/DC technique, the most advantageous and reliable ones being: neutral point clamped rectifier and PWM rectifier [36], [37]. Several factors must be considered during the design stage, including voltage, current, the number of ports, and bi-directional power sharing.

4.1. DC/DC converter stage

DC power is a simpler technology to use, since it only requires a single connection to the grid, making it easier to isolate. On the other hand, because DC converters are less expensive, system installation is less expensive. Control techniques are also simplified because there is no reactive power. Different levels of battery charging time resulted in load diversification. Since partial power is possible, system loss, and converter cost are reduced, which is another advantage of DC distribution systems [38]-[40].

Usually, DC converters typically operate at low voltages of 400 volts or less, high currents in the hundreds of amperes are required. However, high current causes thermal stresses, which reduce efficiency and count as disadvantages. Compact charging stations and low costs are required for more efficient systems. Non-isolated and isolated DC-DC converters are the two main types of DC-DC charging topologies. The main distinction of non-isolated converter topology is the use of a capacitor in both the output DC link and the input DC side.

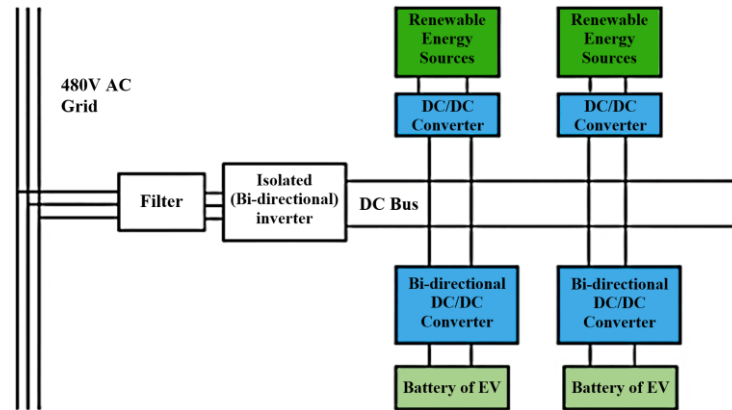


Figure 5. Power architecture of AC EVS

5. POWER ELECTRONICS TECHNIQUES USED FOR FAST CHARGING

The first charging level is 40KW, which can charge a battery up to 20 KWh in 30 minutes [41], [42]. Vehicles with on-board AC/DC converters, as shown in Figure 6 that are powered by 230 volts are not cost effective when compared to fast charging technology. For more than 20 KW, it is preferable to use DC fast charging from the AC supply grid; however, such systems require recent power semiconductor modules with high switching frequencies. Furthermore, these modules are small in size and have low losses. The charging current, which can be controlled, is determined by demand [43], [44]. It also has a wide temperature range and is inexpensive. In the meantime, high reliability over a wide temperature range at the lowest possible cost. Fortunately, it is commercially available at reasonable prices. The advancement of power electronics technology will determine the future of EV charging stations. Fast charging stations must typically operate efficiently for up to 20 years. There is a significant difference between fuel station and electrical charging station, as the failure of the latter may cause EV problems. Since the energy stored in EVs is lower and the charging station network is not as widespread as that of fuel stations, the effects of this are regarded as disadvantages.

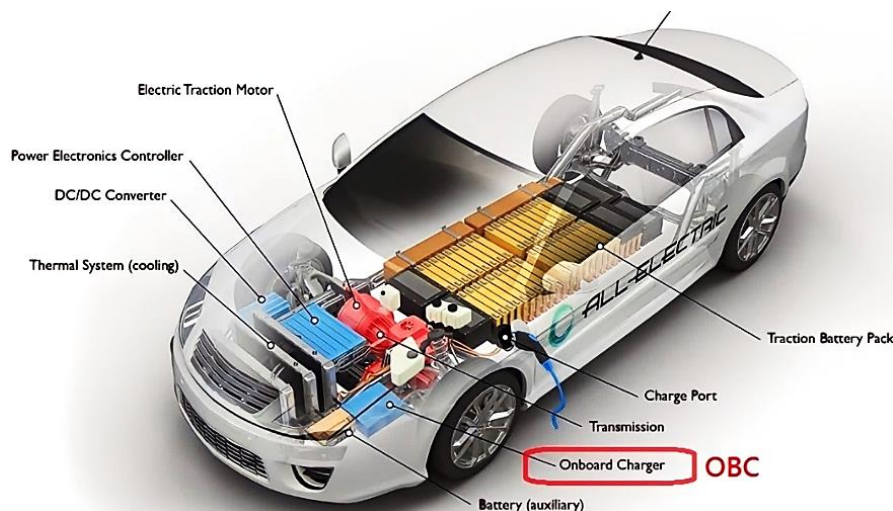


Figure 6. EV on board equipment's

6. RENEWABLE ENERGY SOURCES

The progress of EV charging stations using renewable energy is accelerating, and this is good news for the environment and for EV drivers. Renewable energy-powered EV charging stations help to reduce greenhouse gas emissions and air pollution, and they also make EV charging more affordable and convenient. In addition to solar and wind power, other renewable energy sources such as hydropower, biomass and geothermal power are also being used to power EV charging stations, as shown in Figure 7 [45]. For example, in Iceland, a number of EV charging stations are powered by geothermal energy. As a result, there is now a growing network of EV charging stations powered by renewable energy sources such as PV and wind power.

One of the most notable examples of progress in this area is the development of PV-powered EV charging stations. PV-powered EV charging stations are particularly attractive because they can be located in remote areas where grid power is not available or unreliable. Another important development is the integration of battery storage into EV charging stations. This allows stations to store excess renewable energy generated during the day and use it to charge EVs at night or during peak demand periods. Battery storage also helps to reduce the strain on the grid and improve the reliability of EV charging.

Renewable energy systems provide grid rapid charging and stability, if fast charging for energy storage systems is required. According to the International Renewable Energy (IRENA), report on renewable energy in 2022, wind had 93 GW, while solar energy increased by 19%, with a total installed capacity of 849 GW [46]. The majority of solar energy is installed in Asia, with China leading the way, followed by South Korea. Since the cost of photovoltaic (PV) cells has decreased significantly in recent years, solar energy has become a very important energy source. It has decreased by nearly seven times in the last ten years [47], [48].

Researchers looked into the impact of an electrical power system on its power losses, voltage stability at each node, power system oscillations, (decreased) energy demand response, and ideal charging stations [49]. Since EVs affect the amount of electricity used, optimization strategies must be followed to replicate ideal conditions and energy planning must be carried out to keep the grid operational. As a result, energy management sources must be investigated alongside the most effective EV chargers in order to provide energy from each source throughout the charging process. PV power plants are currently attracting a lot of attention as potential energy sources. PV systems can be integrated into radial distribution network systems (RDNs) to reduce the total power lost by the electrical power system. A step-down power transformer is operated to connect the equipment used to charge the EV to an RDNs. It is used to reduce the system's high voltage level to a more manageable level. Meanwhile, the power cord for the regular charge is connected to a charger at home. Figure 8 depicts PV or wind charging an EV via the DC grid, while Figure 9 depicts renewable infrastructure with DC charging. Here are some specific examples of progress in the development of EV charging stations using renewable energy [50]:

- In the United States, the Biden administration has announced a \$5 billion plan to build out a nationwide network of 500,000 EV chargers, including many that are powered by renewable energy [51].
- In China, the government has set a goal of having 2 million EV chargers installed by 2025, and many of these chargers are expected to be powered by renewable energy.
- In Europe, the European Union has set a goal of having 1 million EV chargers installed by 2025, and the EU is also providing funding for the development of renewable energy-powered EV charging stations.

These are just a few examples of the progress that is being made in the development of EV charging stations using renewable energy. As the EV market continues to grow, it expected to see even more investment in this area.

The progress of EV charging stations using renewable energy has been significant in recent years. This is driven by a number of factors, including: i) The increasing popularity of EVs; ii) The declining cost of renewable energy technologies; iii) Government policies and incentives; iv) Private sector investment.

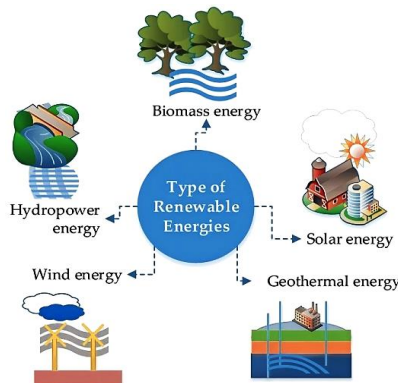


Figure 7. Types of renewable energy sources

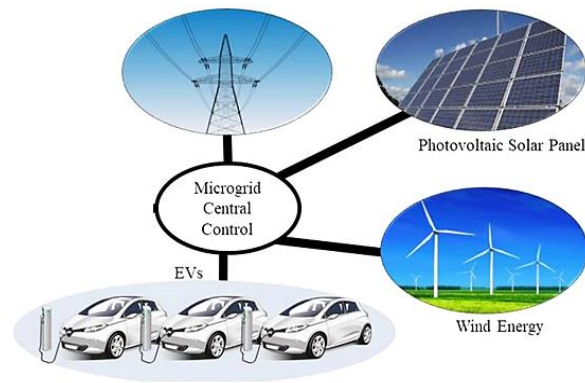


Figure 8. Charging EV through DC grid by PV or wind

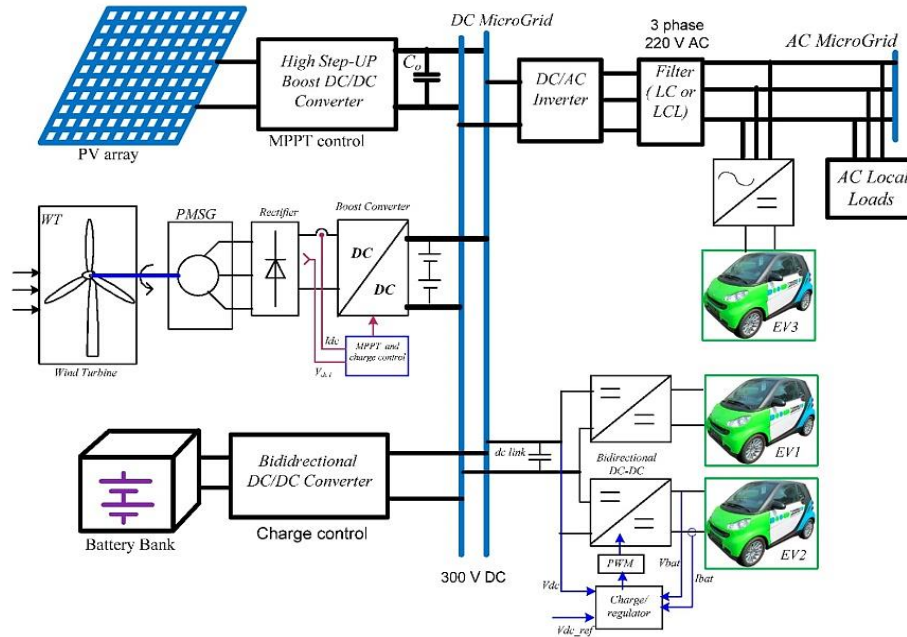


Figure 9. Infrastructure for renewable and DC charging

7. CONCLUSION

It is expected that by 2030, EVs will be advantageous and will account for 10% of all vehicles. The advancement of power electronics technology will result in less expensive EV charging stations and shorter charging times. On the other hand, AC/DC protection and reducing power equipment losses must be prioritized. Sure, using DC charging stations has many advantages over using AC charging stations, not the least of which is their low cost. To have a positive environmental impact, EVs must be supported by governments, so recommendations are provided to get there. This article simply highlights academia and industry by directing research to develop fast EV charging stations. Also demonstrates the significance of future power requirements for EV charging stations.

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